Petroleum
REFINER
FOR THE HYDROCARBON PROCESSING INDUSTRY
AUGUST 1960

HOW TO SPECIFY TRAYS

To specify fractionating trays, the engineer must first decide between two basic types of specifications:

- A *duty* spec
- An *equipment* spec

This report tells you which to use with what tray type

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New Way to Get Relative Volatilities 129
Predict Gas Density at Super Pressures 135
The Fine Art of Developing Managers 145

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Volume 39, No. 8 August 1960

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Petroleum
Refiner

OIL, GAS AND PETROCHEMICAL PROCESSING

A Gulf Publishing Company Publication

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

SPECIAL REPORT: HOW TO SPECIFY TRAYS

☐ **How to Specify Fractionating Trays . . .** This introductory article in the special report covers general conditions an engineer must make in specifying trays, and the main types of specifications written today. An outline check list is included for the spec. writer. By using it, thoughtless omissions are practically impossible. For your copy of the general conditions and spec. writing outline, turn to **Page 86.**

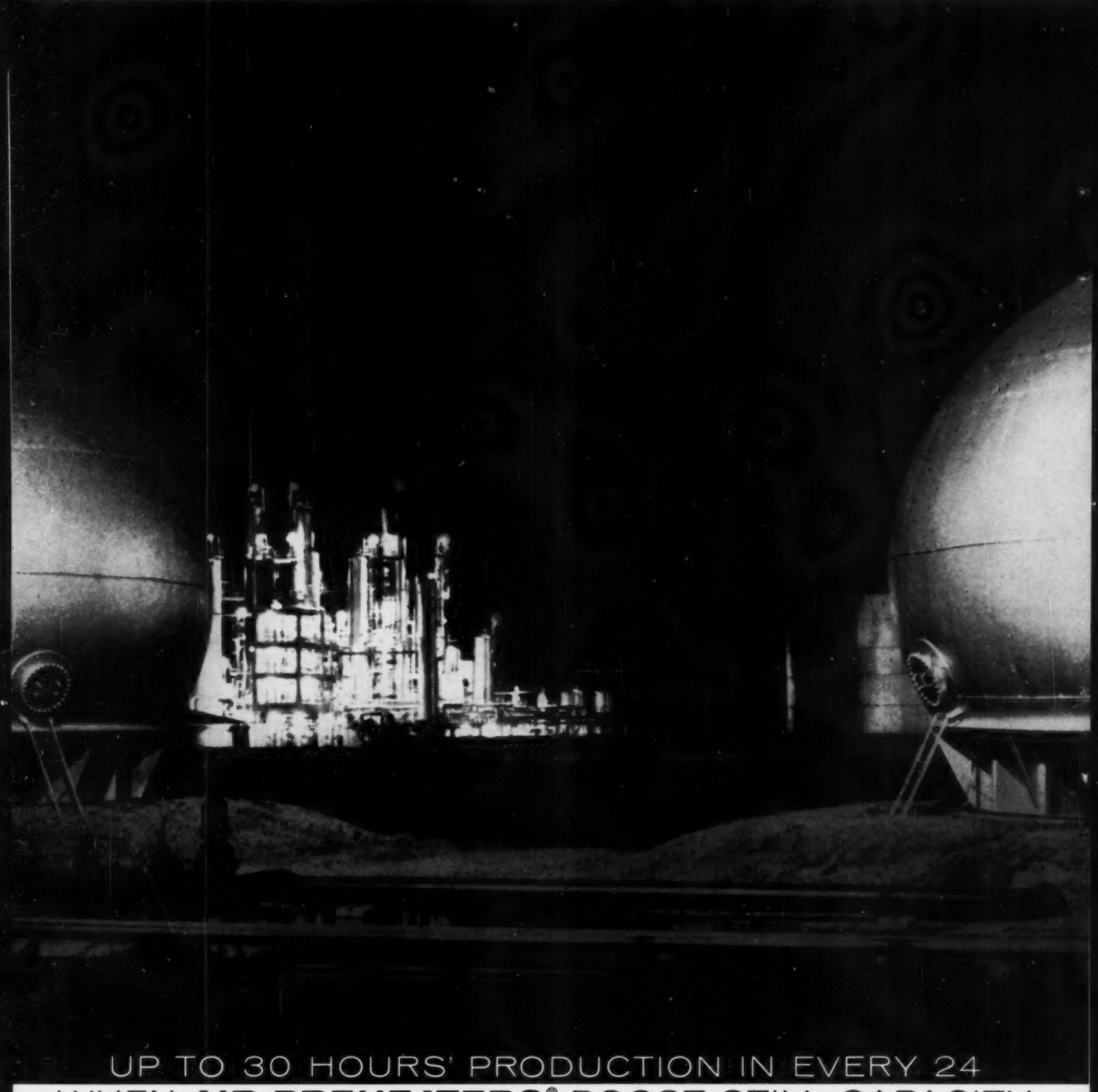
☐ **Mechanical Specification of Trays . . .** After chemical process and metallurgical specifications have been drawn, the tray must be mechanically designed to meet these specifications. Mechanical aspects of tray specification are certainly as important as the process function. To check on what you should cover in your next mechanical specifications for fractionating trays, turn to **Page 91.**

☐ **How to Specify Bubble Cap Trays . . .** The basic fractionating tray for years has been the bubble cap. With many new tray types available today, bubble cap trays are still specified for many services. They are nearly always called for in an equipment specification where the mechanical design of the tray is given. For a complete check list of items needed to complete this type of specification on bubble cap trays, turn to **Page 92.**

☐ **How to Specify Valve Trays . . .** Ethics forbid extending the fabricator's process service into the consulting field (providing heat balances, reflux ratios, etc.) which is foreign to tray design. However, the tray designer-fabricator is obligated to provide an efficient tray to operate under load conditions stated by the process designer. To see what the process designer needs to tell the fabricator when specifying valve trays, turn to **Page 93.**

☐ **How to Specify Sieve Trays . . .** There are two widely diverse opinions on hole diameters in sieve trays. Some prefer relatively large holes (½ to 1-inch diameter) while others like small holes ($\frac{3}{16}$-inch diameter). This point and all others needed to specify sieve trays can be found on **Page 95.**

Please Turn Page ➔



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A Quick Look at This Issue . . .

☐ **Automatic Blending Lives Up to Goal . . .** This case history shows automatic gasoline blending to be superior to batch or partial on-stream blending. See how Sohio was rewarded for incorporating automatic blending in its Toledo refinery. Just turn to **Page 97.**

☐ **New Vacuum System Speeds Unloading . . .** Addition of a pipe loop and one valve converts a conventional unloading system into a more flexible system. See how a small initial investment can be justified by shortened transfer time. Turn to **Page 101.**

☐ **Tube Rolling Techniques Are Changing . . .** Higher temperature and pressure heat exchange equipment requires better tools and techniques for tube rolling. Here, the various methods are summarized, giving advantages and disadvantages of each. To see which is best for you, turn to **Page 104.**

☐ **Need More Data on Trialkylaluminums? . . .** You have in this issue the latest information to help evaluate applications and reactions of these newest petrochemicals. They're interesting and useful. To see for yourself, turn to **Page 109.**

☐ **Applied Hydrocarbon Thermodynamics . . .** Part 20. P-T-C K-Charts for Vapor-Liquid Equilibria in Hydrocarbon Systems . . . Here are P-T-C charts for 16 hydrocarbons along with sample calculations on the use of these charts for equilibrium K values. See **Page 113.**

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☐ **Figure Distillation This New Way (Part 4) . . .** Optimum operation of a distillation column can be specified with the aid of a digital computer and the new convergence method discussed in this series. In this part, equations are proposed for the two limiting conditions of a conventional column: Total reflux and total reboil. Side streams are also considered so that you can handle a variety of situations with this method. Turn to **Page 121.**

☐ **How to Check Job Overhead Accounts . . .** Most overhead items are listed with a complete description. Begin now to carefully consider each of these items when building a job estimate. Turn to **Page 127.**

☐ **New Way to Get Relative Volatilities . . .** Relations depicted in a Cox-type of vapor pressure chart are transformed here into one equation. The result is an easier and more accurate method for predicting relative volatilities. Now you may figure α's knowing only the normal boiling points of the materials, by turning to **Page 129.**

☐ **Operator's Handbook for Gasoline Plants . . .** This part on exchangers and tanks tells how exchangers are made and operated and how tanks are designed. Operators will want to add this part to their storehouse of understanding. To learn more, turn to **Page 133.**

☐ **Z for High P and T . . .** Whenever you want the density or any of the P-V-T relations for gases or gaseous mixtures at super pressures and high temperatures, you may find your charts do not cover the high range. Also, when you have considerable hydrogen in your mixtures, this chart will give you greatly improved accuracy. You'll like this one . . . see **Page 135.**

☐ **How Power Affects Employe Appraisal . . .** Applied Group Dynamics: Part 4 . . . Employe morale depends a great deal on the way a supervisor handles employe evaluations. This article brings to light some extremely interesting points which you will do well to remember whenever you are being appraised —or when you are appraising others. You're going to want to clip this article and add it to the others in this series, so turn now to **Page 141.**

☐ **Developing Managers . . .** In reading these principles for the development of humans, some will say, "Of course, everybody knows that." Actually though, these principles which are obvious to some are more often ignored and violated than observed and honored. You'll want to be sure to read this highly interesting and informative article on how you can help yourself and others grow in a business organization. Turn now to **Page 145.**

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- **Eliminates normal "hot spot" below fixture**

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GO TO ANY of 1959's conventions held by associations or societies in the HPI field? If not, and if you are a PR subscriber, we helped you save, on the average, 141,742 miles of travel, 185 days of meetings, $9100. in air fare and $4600. in other travel expense. How? Well—

Last year our editors reviewed, as being of interest to PR readers, 68 programs from 32 societies. Of the 5486 papers offered, we found 512 worth scanning and from these we picked 186 for thorough review. Finally, 46 were selected for publication. So besides the travel time and money saved, PR's systematic searching for and publication of the outstanding contributions saved our readers the monumental job of plowing through nearly 5500 papers to find 46 of real value.

It reminds one of the Federal budget, but subtracting, say, 2000 of our subscribers who did attend these meetings, we saved the other 22,000 a grand total of $302,000,000.

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Handbook Insurance

ABOUT THIS TIME every alternate year we remind our readers that they'd better check their subscription status so as to be sure to get a copy of PR's Process Handbook to be issued in September. Or, if they are certain as to their own, check their friends so that between now and September '62 they won't have to be forever lending. (And sometimes not getting back.)

The 1960 edition will contain a total of 85 processes, 11 of them developed since the previous edition in 1958. And many others have been added in order to make the Handbook even more complete.

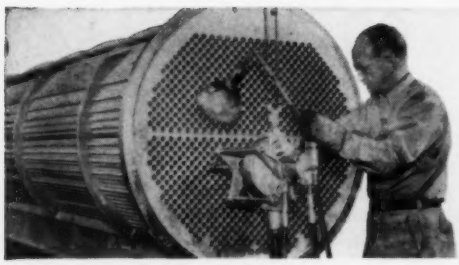
So make sure you are on the list and, just about as important, check Ol' Borrowing Ben so that you can be reasonably certain that your copy will enjoy comparative safety. Just to be sure, suppose you ask him about it right now in a memo clipped to the postal card that faces Page 3!

Red's Hot Message

"RED" MOTLEY doesn't register quite as well in print as he does in person, but at that he seems to "get across" no matter what the medium.

"Red" was in Houston recently and his ringing advice was along this line: "Get into politics yourself or don't quarrel if there develops a government that people in business and industry will find most distasteful."

When invited to contact through PETROLEUM REFINER men in HPI, "Red" lost no time, because truly there's no time to lose. His message appears on Page 13 of this issue, and if you are really concerned about our nation today and tomorrow, you are urged to turn three sheets and start reading. Then—and this is most important—*act*.



CONDENSER AND HEAT EXCHANGER CLINIC

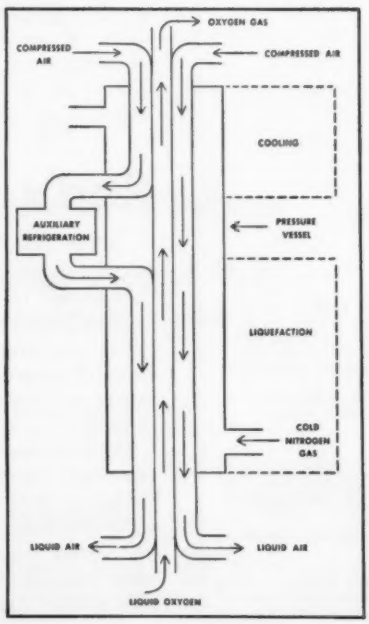
Edited by Arthur W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

Cryogenic heat exchanger uses 16 miles of copper tube

A copper-tube heat exchanger used in the production of oxygen and nitrogen in a large low-temperature processing plant made by AIR PRODUCTS, INC., Allentown, Pa. The ⅜" tubes are wound tightly and built up layer by layer for greatest possible surface contact – and maximum heat transfer between the oxygen and air tube systems (see diagram below). AIR PRODUCTS winds bundles from long lengths of Anaconda tube. A total of 85,200 feet is used in this exchanger, for a total weight of 14,500 pounds. The "button-hook" manifolds for the tube systems are of Red Brass pipe, with extra-heavy or double-extra-heavy wall.

In applied cryogenics – the use of low-temperature techniques for gas liquefaction and separation and for the handling and application of these gases – the unique properties of copper and copper alloys become particularly important. The high thermal conductivity of copper–the highest of any commercial metal – is essential for economical heat transfer in large volumes of fluids. Outstanding corrosion resistance is important. And finally, copper has no tendency to brittleness at very low temperatures, and the strength of copper and copper alloys is significantly higher at –300F than at room temperature.

The use of low-temperature processing and of liquefied gases is rapidly increasing in the chemical industry, in basic metals industries, and in space and missile fields. And new applications are being found constantly. American Brass Company specialists are available to help select the alloy best suited to your job. For more information on tubes for heat transfer, or for technical assistance, write: The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.



Schematic diagram of heat exchanger used in the production of oxygen and nitrogen. Incoming air under pressure passes through a set of coils in the exchanger and is cooled by counter current heat exchange by cold outgoing oxygen and nitrogen. Oxygen from the distillation column enters the heat exchanger as a liquid under pressure and, in removing heat from the air, vaporizes to a gaseous form and leaves the heat exchanger at near entering air temperature. Part way through the heat exchanger, the air is removed from the heat exchanger and sent through a Freon cooling system for auxiliary refrigeration and then returned to the exchanger for final cooling.

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Quick Look at Industry...

Let's Play Musical Chairs . . .

Many companies look to reorganization as way to streamline operations. Goal: reduced costs. In the Game: Standard of Indiana becomes parent company with broad management policy while its subsidiaries, American Oil and Utah Oil Refining, combine . . . Texaco reorganizes Research & Technical Department for "growth flexibility" . . . Humble takes in newly merged Oklahoma Oil and Pate Oil as new division . . . Cities Service forms new petrochemical division.

Also Pan American picks up 50% interest in Texas Gas and Gulf buys Wilshire Oil.

OCDM to Study Asphaltic Crude Exemption . . .

Proposal by four major companies to exempt asphaltic crude from import controls to be studied by Office of Civil and Defense Mobilization. Proposal made by Atlantic, Standard of California, Indiana Standard and Cities Service.

OCAW Seeks 18-cent Pay Hike . . .

Bargaining Committee of OCAW sets new bargaining goal of 18 cents per hour for locals in petroleum industry . . . first policy action since union's "reconstitution" last year. Breakdown, says union, includes 6 cents for cost of living—12 cents for "increased productivity."

Looking Over the Demand Scene . . .

Domestic crude to be consumed or exported in August is 7,125,000 bpd compared with 6,995,000 bpd for July, estimates Bureau of Mines. The breakdown: gasoline demand—4,565,000 bpd, 5.4% above like 1959 period; gasoline yield—46.3%; total crude runs—8,100,000 bpd.

Total gasoline demand for third quarter to be 1.6% above same period last year, says Du Pont report. This compares with 2.6% increase for second quarter of 1960 over 1959. Lower growth for third quarter reflects unusual high volume of sales last year to dodge federal gasoline tax increase imposed after October 1, 1959.

Production of some crude products from petroleum and natural gas reflects big gain over 1958 production. Naphthenic and aromatic products soar 28% to 6.8 billion pounds—while benzene jumps 47% over 1958.

IPAA Calls for Continued Restraint . . .

Continued restraint during remainder of third quarter called for by Independent Refiners Association of America. IPAA says "much progress has been made in correcting excess refined product inventories during second quarter."

WOGA Asks for Stronger Smog Law . . .

Western Oil and Gas Association urges strengthening of Rule 62, Los Angeles County smog law limiting fuel oil burning to 5% sulfur content from May-October each year. Association is still studying effectiveness of rule.

Greaseless Bearings Around Corner . . .

Long-talked-about greaseless bearing may be here at last. Ford Motor Co. considers using fluorocarbon-resin-type lube-free bearings in steering and front suspension of some 1961 models. Cars would then need lube job only at "10,000-mile intervals."

USSR Continues Threat to Crude Markets . . .

Russia again flexes economic muscles in deal with India. The product: oil. The problem: USSR made three-year deal with India for crude at 12

cents below world-market rate. Stanvac countered with offer of "fully competitive" prices—Caltex continued to dicker. With Soviets number three in world production capacity, international oil battle could emerge.

Quick Look Around the World . . .

Number of buses, cars and trucks on world's highways increases 86.4% over 1950 figure. In January 1950 there were 63,200,500—in January 1960, 117,788,400 . . . President of Petroleo Braziliero says Brazil's refining capacity will meet nation's need by end of 1960 . . . Interior Department establishes Office of Coal Research under Coal Research Act . . . Texaco's Port Arthur refinery sets world safety record—7.65 million plus man-hours without lost-time injury.

Washington Loses Patience with Castro . . .

U.S. ditches "wait and see" attitude toward Cuban Prime Minister Fidel Castro. Cuba's expropriation of Texaco and Esso refineries, plus move against utility firms and efforts to get Greek tankers to ship crude from USSR, convince Washington that Cuba aims to be latest child in Communist family. Result: A big slice in Cuba's sugar quota—U.S. admits to Organization of American States that attempts to reason with Castro have flopped.

Quick Look at World-Wide Construction . . .

India gets first synthetic rubber plant. Built for Synthetics and Chemicals, Ltd., $30-million project to be near Bareilly . . . World's largest ethylene plant slated for Mobil Oil, Beaumont, Texas . . . Suntide Refining to construct 60-million-pound-per-year styrene unit, Corpus Christi, Texas. Construction to start in November—be complete early in 1962 . . . Celanese eyes major expansion of higher acrylate esters production at Pampa, Texas—capacity to be about 14 million pounds. For more on construction, see page 160.

Industry Blasts GATT List . . .

U.S. chemical leaders pour into Washington late in July to talk government out of cutting tariffs on many synthetic organic chemicals. Fight emerges as biggest struggle in decade against further liberalization of U.S. trade policies. Big issue: Government's plan for international trade negotiations under General Agreement on Tariffs and (GATT) at Geneva, Switzerland, in fall—sixth such meet since end of World War II.

Eyeing the Political Picture . . .

More government intervention in business would keynote Kennedy administration. Evidence comes from Democratic platform, Kennedy's voting record and statements. Views on economic expansion parallel Nixon's—but Massachusetts Senator would push higher wages and full employment—while Nixon stresses investment incentives and tax policy.

Certified Technicians Ahead . . .

Organization to certify technicians in engineering and physical sciences is formed by National Society of Professional Engineers. Registered engineers will team with qualified group of engineering technologists to govern organization.

U.S.S.R. and U.S. to Swap Oil Tours . . .

Time: First week in August. Destination: Russia. The Travelers: Eight top U.S. oil company executives—all on official trip to look over Soviet refineries, offshore drilling in Caspian Sea, and Baku field operations. Party will be accompanied by Russian-speaking oil and gas specialists from Interior Department. Russia will send similar group to U.S.

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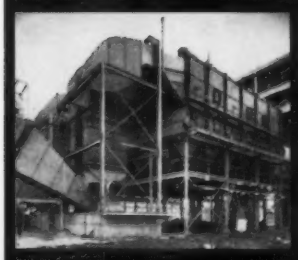

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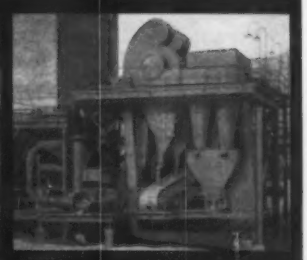
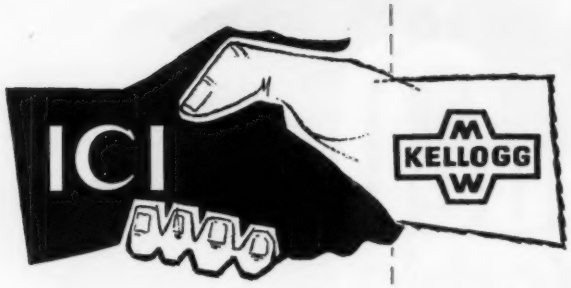


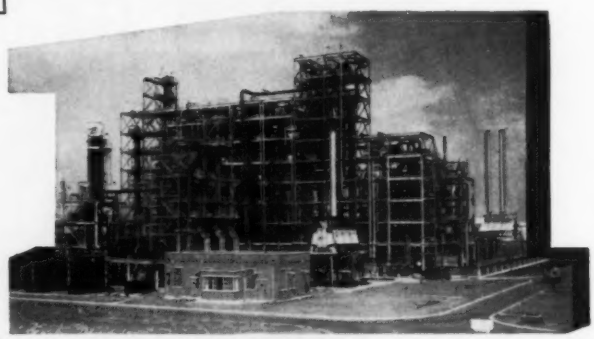
CLASSIFIERS Capacity to keep up with any mill . . . low power consumption, no moving parts.



KELLOGG BUILDS FOR I.C.I. EXPANSION

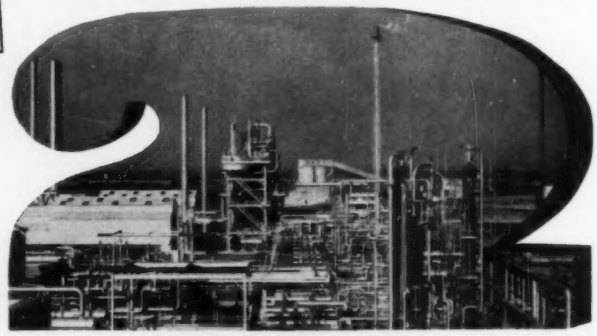
1951

Recent completion of Imperial Chemical Industries' third olefin plant at Wilton, England, has made these Works the largest petrochemical venture outside the United States. With a current output of 110,000 tons per year of high-purity ethylene, and a potential output of 140,000 tons, I.C.I. Wilton is an outstanding example of engineering cooperation.



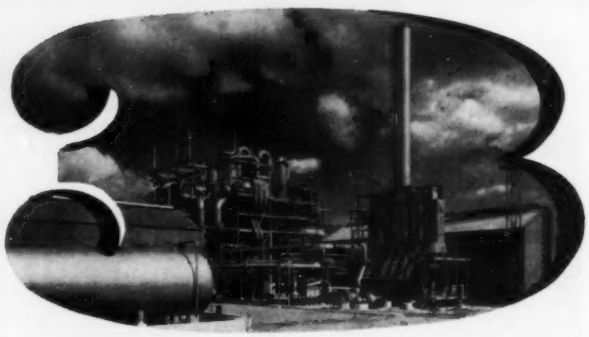
1956

The first plant was commissioned in 1951, and was the first full-scale adoption of the then novel process of oil pyrolysis developed in the Kellogg Laboratories. Its success led to the addition of No. 2 plant in 1956, and then to this latest extension, representing a 60% increase in olefin capacity, in 1959.



1959

Cooperation between client and contractor is the keynote of Kellogg's contribution to chemical engineering. The Wilton Olefin Plant is the largest in the world based on liquid feedstock. Kellogg is proud to have been associated with its development.



To learn more about Kellogg's background in engineering and building olefin plants, at home and overseas, write for current Kelloggram

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YOU Have a Job in Politics

Arthur H. Motley, President, Chamber of Commerce of the United States and President-Publisher, Parade Magazine

TODAY'S BUSINESSMAN can fulfill his obligation for the betterment of government only by working with real zeal for his party and his candidates.

You can start today in helping to get qualified people into public office. With national elections so close, both major political parties can use all the assistance they can get. But don't forget—the businessman's new role in working politics doesn't end in November. From now on, businessmen—as individuals—are in politics up to their ears 365 days a year, every year.

The government of the United States, on the local, state and national levels, is government by the people. The more citizens who take an active part in government, the better that government will be. This is the reason as many people as possible must participate in politics. (It goes without saying, of course, that this must be an informed electorate—and that management has a responsibility to help create an informed citizenry.)

Get In It! For years, businesmen have felt that politics was outside their bailiwick; that talents used in the business world have no place in the political parties. Nothing could be farther from the truth. The organizational and administrative abilities essential to any good businessman are precisely the abilities needed in politics. Whether you are a Democrat or a Republican, there is a spot for you in your party's organization.

You won't start out as county chairman—how many corporation presidents do you know who started out as corporation presidents?—but you will be welcomed and put to work. Volunteer to work at party headquarters. Things you can do there include jobs as simple as answering the telephone or as highly specialized as giving legal advice and preparing campaign leaflets and publications. Speechmaking is important in any campaign. Join or organize a speakers bureau to arrange speaking engagements for candidates, write speeches for others and provide speakers when needed. If study and analysis is your field, join your party's research committee and compile information on candidates and issues. Raise money. Write letters. Be a block worker and/or poll worker. Become a precinct worker or precinct captain. Join a political club. The list of things you can do for the party of your choice is virtually endless. Just be sure to to *something*.

So far, we've been talking about what you as an individual can do in politics. If you're an employer or an official of a company, it is important that you set a good example. One big reason more employes don't take part in politics is that they are not sure how management feels about it. If they see the boss in there pitching, they know they can help, too.

An excellent way to clarify company position on political activity is to publish a policy statement. The statement can be published in employe publications, placed on bulletin boards or distributed to employes individually. The policy can be simple or complicated.

Western Electric Co.'s policy says "It is the policy . . . to stimulate and encourage individual expression and action in the political life of the community."

Standard Oil Co. of California's statement is brief: "The Company believes that good citizenship for the individual also involves taking an active interest in governmental affairs and politics, giving time to political parties and candidates of his choice, and giving serious consideration to the assumption of public office himself."

Continental Oil Co.'s policy, on the other hand, is detailed and provides for payment of employes who take time off to participate in politics. Ford Motor Co.'s statement, in addition to pay, provides for accrual of company benefits while an employe is serving in elective or appointive public office.

Helps in Other Ways. Besides adopting a policy statement, there are other things a company can do to encourage employes to vote, contribute and work in the party of their choice. First, workers should be given time off to vote. Faultless Caster Co., Evansville, Ind., sends each employe a card which tells him his ward and precinct and lists the Democratic and Republican precinct chairmen. The date of the election is given and telephone numbers and the names of people to call for information are listed. On election day, all Faultless employes on the day shift are excused at 2 p.m. to vote.

Employers can help workers become familiar with issues by discussing them in company publications,

From seven great Solvay plants (Baton Rouge above) stream chemicals vital to petroleum production, refining and petrochemical manufacture—caustic soda, caustic potash, aluminum chloride, chlorine, calcium chloride, and many more.

How Solvay Chemicals Serve the Petroleum Industry

Increasing demands for a diversity of chemicals satisfied by America's pioneer producer of alkalies

From the primitive Drake Well of 1859 to the complex "cat crackers" and petrochemical plants of today, oil's appetite for chemicals has grown enormously—both in the number and variety of products consumed. Closely paralleling this need, the Solvay® line of alkalies and related chemicals has been continually expanding for almost eighty years. Many of Solvay's fourteen branch offices and seven manufacturing plants are strategically near oil production and refining centers. Fast dependable supply is further assured by over two hundred local stockpoints and a nationwide network of responsible distributors. Technical service is available through skilled representatives backed by years of experience in the handling and uses of Solvay chemicals in many industries.

Major Uses of Solvay Chemicals in Petroleum

Potassium carbonate—To remove carbon dioxide and hydrogen sulfide from process gases.

Aluminum chloride—To produce detergent intermediates and other alkylates.
For isomerization.
For polymerization.
For manufacturing ethyl chloride used in tetraethyl lead.

Caustic soda—For treating applications—i.e., the removal of hydrogen sulfide and lighter mercaptans.
For doctor sweetening.
To neutralize acid treated oils.
To neutralize acidic product streams.
For electrical desalters—to control pH of their precipitated brine solution.

Caustic potash—For treating applications—i.e., the extraction of mercaptan from light petroleum fractions. Its higher reactivity and lower viscosity enables faster, more complete separation.
For desulfurizing petroleum products because of its high reactivity.
For Dualayer® Distillate Process.

Calcium chloride—A desiccant for drying LPG streams.
To recover oil from waste. Its strong electrolytic action breaks oil emulsion.

Carbon tetrachloride—For solvent extraction processes.

Chloroform—For solvent extraction processes.

Chlorine—For water treating.
For manufacturing hypochlorite used in treating gasoline.
For producing petrochemicals.

Soda ash—For water treating.
To liberate DEA from heat stable salts.

Sodium nitrite—To combat corrosion.
Used with nitrates as a heat transfer medium.

Vinyl chloride monomer—To produce plastics and surface coatings.

Chromium chemicals—To prevent water-side corrosion.
To prevent corrosion in recirculating water systems of cooling towers.

MAIL TO SOLVAY if you want further information on these products or applications. Describe below or accompany with a letter.

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Send export inquiries to Allied Chemical International, 40 Rector St., N. Y. 6.

at meetings and on bulletin boards. General Electric News published a special issue just before the New York state legislature's session got under way. In it a company official urged the legislature to take action in major areas of the economy. Employes were encouraged to give legislators their views on problems facing the state.

Other companies run special articles on Congressmen and Senators who represent areas in which plants are located. Employes can see how their Congressmen and Senators voted and companies can point out how the votes affected industry, management and employes.

Contribute-and-work and contribute-and-vote campaigns are very effective. Aerojet-General in 1958 urged all employes to contribute to the party of their choice. Contributors were given "Good Citizen" stickers to affix to plant badges. Departments in which all employes contributed were given special certificates of recognition. Special "Good Citizenship" committees, made up of secretaries, union men and shop stewards, supervisory people and company officers, were formed to keep the program moving. At the same time, special facilities for registering were set up inside plants. In three weeks, 11,000 of 15,000 employes contributed an average of $2.30 each for a total of $25,000 to both parties. A total of 2000 new voters registered. Ford has just begun a contribute-and-work plan.

Take the Course! The best way to encourage employes—and yourself—to participate in politics is to take part in a training-in-politics course which provides a firm foundation of political knowledge. One of the best of these, and by far the most popular, is the Action Course in Practical Politics designed by the Chamber of Commerce of the United States. An estimated 100,000 citizens have been through this course. A large percentage of them are active in politics as a result. The course takes nine weeks, with a two-hour meeting once a week. Groups of 12 to 20 people participate in the discussion-type meetings.

Each participant reads a pamphlet before coming to a session. The pamphlets are called "The Individual in Politics," "Political Party Organization," "The Political Precinct," "The Political Campaign," "Political Clubs," "Political Leader's Problems," "Political Meetings," and "Businessmen in Politics." At the ninth meeting, working politicians from both parties in the community visit the discussion group to answer questions.

The Action Course is truly practical. It teaches the working side of politics. No theories, no issues. Graduates are getting into politics all over the country. Perhaps the "star graduate" is Congressman Herman T. Schneebeli of Pennsylvania, who ran for Congress just after finishing the course. He is a Gulf Oil distributor, by the way.

For information on the Action Course, contact your trade association or local chamber of commerce, or write the Business Relations Department, Chamber of Commerce of the United States, 1615 H St., N. W., Washington 6, D. C. A set of pamphlets (one set per participant) costs $6; a Discussion Leader's Manual (one per discussion group), $12.

Even though there is barely enough time to complete a course before the November elections, participate in one anyway. It will prepare you to work in the party of your choice after the elections. And there will be a lot of work to do after this election, regardless of who wins. The citizen-in-politics movement sparked by business is well under way. It is going to get bigger and bigger in the years to come—if we all get into politics and *work*.

No Relaxation In Research EACH DOLLAR invested during the past 10 years by Esso Research and Engineering Co. in developing new or improved processes or products has yielded benefits worth $7.

This, one of the definite measurements of Standard of Jersey's research program, is set forth in the current issue of *The Lamp*. Significant statements contained in the article signed by President M. J. Rathbone include these:

- *"It would be hard to overstate the importance of research in the oil business."*
- *"Our company considers its widespread research activity an essential tool of management, an investment in the future that will keep our operating affiliates progressive and competitive."*

And, of course, what Jersey has done and is doing may be multiplied many times over because other major companies are just as zealously pursuing research programs which in the end spell progress—and survival—for the oil industry. (Progress, perhaps all admit; survival, we suggest because where would the oil industry be today in the world economic picture if its 101-year span were not studded with scientific developments which have resulted in more and better products for the consumer dollar?)

This company—Jersey—alone claims such headline inventions as Fluid catalytic cracking and butyl rubber. But there are hundreds of other processes or products perhaps of lesser importance developed by their scientists which rate as real contributions to the public at large. And, of course, to the industry itself.

Example: Jersey scientists recently found a way to reduce the rate at which carbon is deposited on catalyst particles in cat cracking units. Since carbon lessens the effectiveness of the catalyst and must eventually be removed, less carbon means lower cost operation. "The importance of even a small reduction in the rate of carbon accumulation becomes apparent when one considers that the refineries of Jersey affiliates have approximately a million barrels per day of catalytic cracking capacity," Mr. Rathbone points out.

All of which observations and claims lead us to add as our final sentence another significant statement with which the Jersey head concludes:

- *"Needless to say, we plan no relaxation but rather an intensification of our pursuit of new ideas about our business."*

PREDICTING ROAD PERFORMANCE OF FUELS IN 1960 CARS

Ethyl Research Develops New Coefficients for Road Rating Equations

by **H. J. SEWELL,** *Refinery Technology Division, Ethyl Research Laboratories, Detroit, Michigan*

Data on the road performance of gasolines are essential for selecting the most economical processing or additive route to produce the fuel antiknock quality that will meet the changing needs of the car population. There is little doubt that road tests provide the best yardstick for measuring the ability of gasolines to satisfy individual cars and the car population. However, road testing is both costly and time-consuming.

To help refiners save time and money, Ethyl developed a now widely accepted procedure for calculating road octane performance from routine laboratory test data. Now Ethyl has computed new equation coefficients with which road ratings may be calculated for 1960 cars, using both the Modified Uniontown and Modified Borderline methods. Coefficients have been developed for road ratings during part-throttle operation as well as at full-throttle.

Here's The General Equation

The relationship of road performance to laboratory variables is expressed in the following equation:

$$\text{Road ON} = a + bR + cM + dO$$

where R = Research octane number
M = Motor octane number
O = Olefins, vol %

a, b, c, and d are equation coefficients for particular cars and tests. The coefficients for premium gasolines based on ratings in four 1960 premium-fuel cars are shown in Table I.

Since the antiknock effect of TEL is greater on the road than in the laboratory, it follows that adding a TEL factor to the general equation significantly improves predicting accuracy. These new coefficients are shown in Table II.

Use of the Equations

Experience with these equations has shown that they are useful in calculating road performance of fuels that are similar in antiknock quality and hydrocarbon composition to those used in the development program.

Since a wide range of full-boiling commercial gasolines was used to develop the Ethyl equations (Table III), they can be used for almost all current gasolines.

Although road octane numbers assigned to gasolines by one vehicle are not necessarily reproducible in other vehicles of the same make and model, experience has shown that *relative* fuel ratings are consistent from car to car.

Ideally, therefore, the equations should be used to *compare* the road performance of gasolines rather than to obtain the road octane number of a specific fuel. In fact, the same reasoning also applies to experimental road-rating results.

Many refiners have found these equations useful in:

1. Analyzing the effects of laboratory properties on road performance when designing current motor fuels;

2. Predicting future trends in the road performance of motor fuels.

For more data on advertised products, use Readers' Service Cards, last page.

TABLE I

Equation Coefficients for Premium Fuels (4-Car Average)

Road ON = a + b(RON)+c(MON)+d(% Olefins)

		a	b	c	d	Stand. Error
Modified Uniontown		37.081	0.268	0.391	–0.041	0.59
Modified Borderline	2000 rpm	24.673	0.473	0.316	–0.020	0.61
	2500 rpm	24.966	0.457	0.319	–0.036	0.66
	3000 rpm	24.738	0.381	0.394	–0.059	0.76
	3500 rpm	16.257	0.345	0.517	–0.079	0.84

TABLE II

Equation Coefficients for Premium Fuels, TEL Factor included (4-Car Average)

Road ON = a + b(RON)+c(MON)+d(% Olefins)+e(ml TEL/gal.)

		a	b	c	d	e	Stand. Error
Modified Uniontown		42.942	0.273	0.313	–0.048	0.289	0.53
Modified Borderline	2000 rpm	31.851	0.479	0.221	–0.028	0.354	0.51
	2500 rpm	34.266	0.465	0.195	–0.046	0.484	0.53
	3000 rpm	34.341	0.389	0.266	–0.070	0.474	0.65
	3500 rpm	25.702	0.353	0.391	–0.089	0.466	0.72

TABLE III

Full-Boiling Premium Fuels Used To Develop Coefficients

Variable	Range	Average
Research Octane Number	96.7—104.3	100.4
Motor Octane Number	84.2—97.1	90.6
Aromatics, vol %	7—57	27
Olefins, vol %	1—46	20
Saturates, vol %	34—87	53
TEL, ml/gal	2.0, 4.0	

How Ethyl Research can help you

Three publications that will enable you to calculate gasoline road performance from laboratory test data are available:

1. "Road Octane Correlations for Premium Gasolines, 1960"
2. "Road Octane Correlations for Regular Gasolines, 1960"
3. "Part-throttle Road Octane Correlations for Premium Gasolines, 1960"

Copies of these reports are available from your Ethyl Representative, or by writing Ethyl Corp., 100 Park Ave., New York 17, N. Y.

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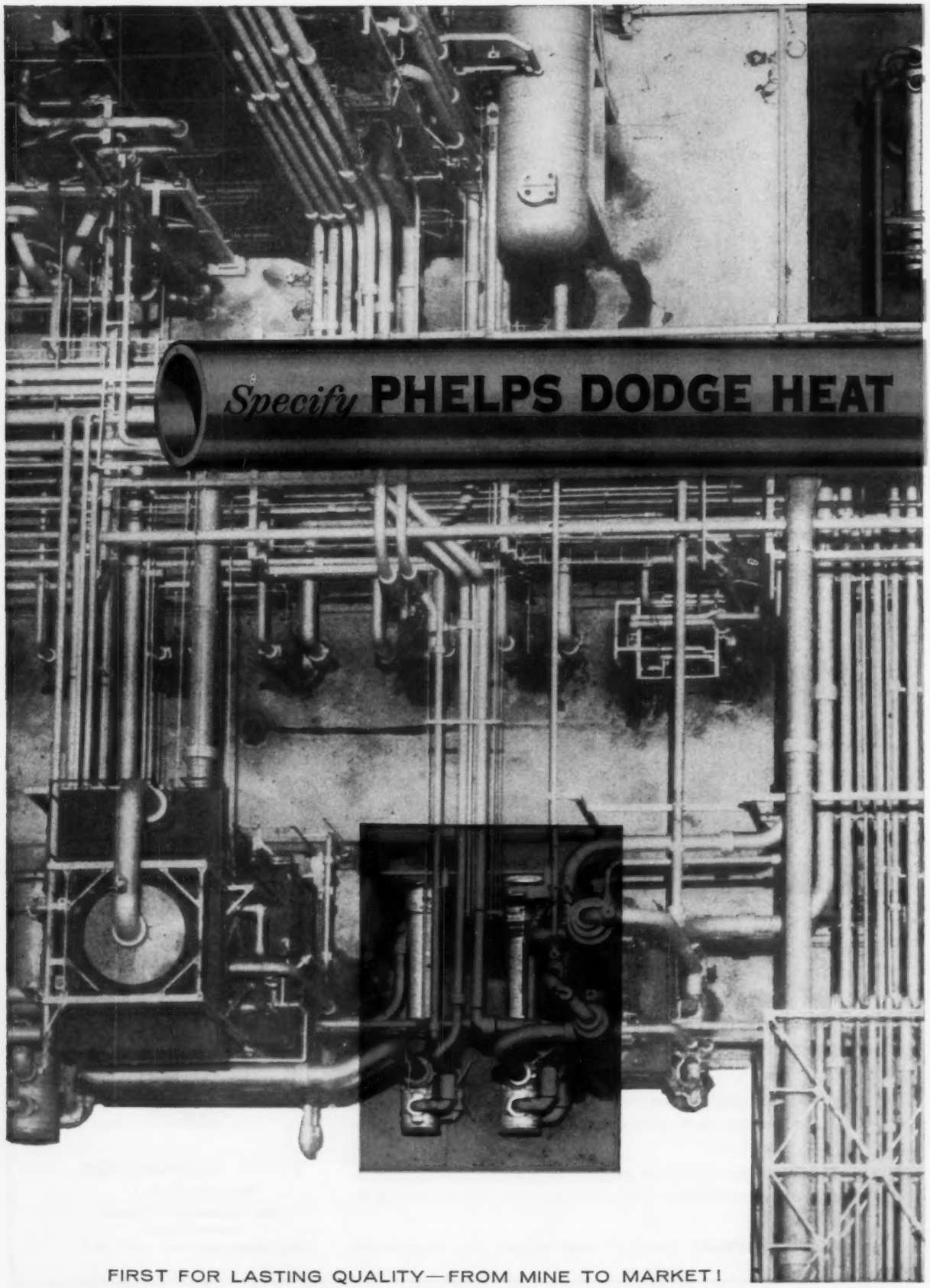

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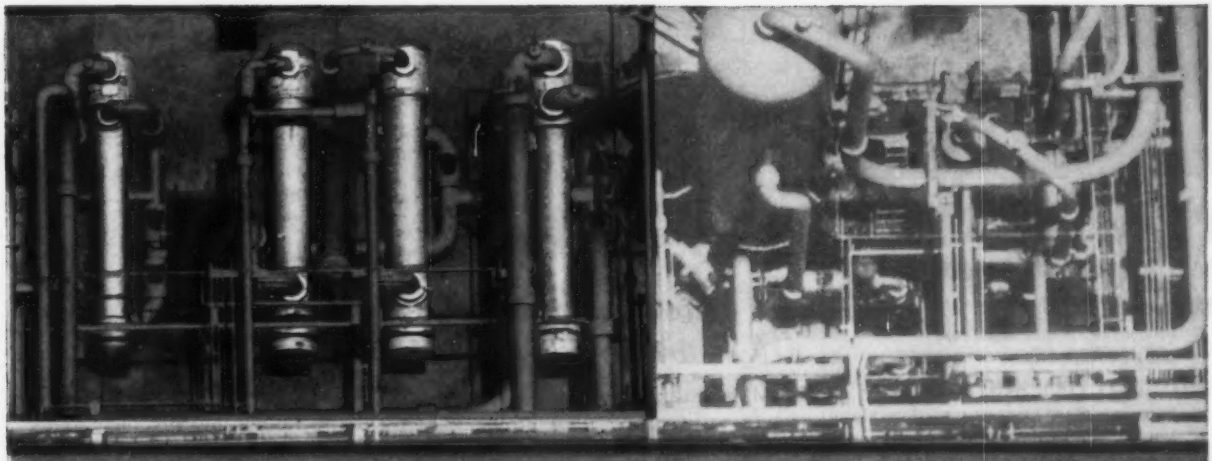

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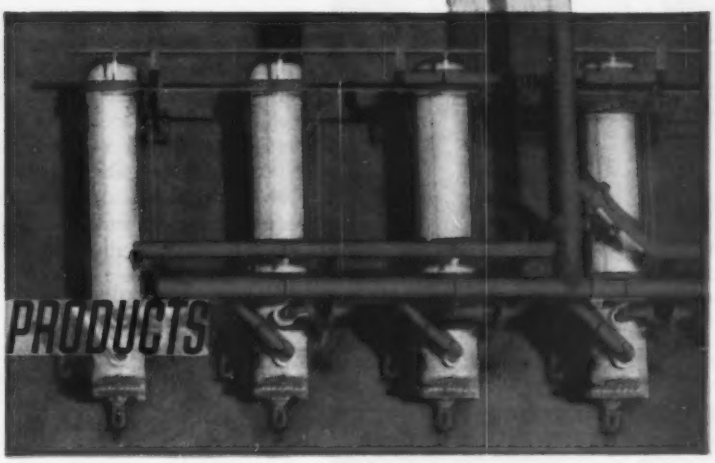

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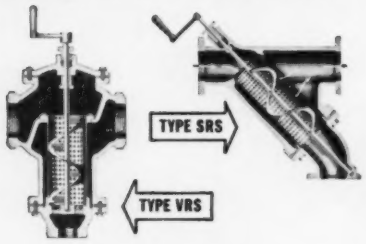

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INDUSTRY IQ QUIZ

Test your industrial IQ with this quiz on the current issue of PETROLEUM REFINER

1. Most antiknock unloading systems require sufficient vacuum in the receiving tank to prime the transfer line. This step can take from twenty minutes to one hour. How can this time be reduced greatly?
- (a) By pressurizing the delivery vessel.
- (b) By creating a vacuum only on the transfer line.
- (c) By lowering the receiving tank.

2. A *duty* specification for distillation columns defines the vapor rates, liquid rates and densities. An *equipment* specification describes the trays: the number required, the diameter, the vertical spacing, probably the downcomer dimensions, the free area through the vapor passages, and much other detail. True or False?

3. When specifying valve trays, you should call for leakage tests. True or False?

4. Only one point of operation for a distillation column with a fixed number of plates and a given reflux rate will yield the maximum concentration of a given component in the distillate or bottoms product. True or False?

5. One answer to the following question is incorrect: Why do you need to "roll" heat exchanger tubes?
- (a) To obtain a good hydraulic and mechanical joint.
- (b) To get a seal that is durable.
- (c) To get a seal that is free of transverse tube stress.
- (d) To get a seal that will resist crevice-corrosion.

6. To predict the relative volatility of two hydrocarbons at a certain temperature, what else do you need to know besides their normal boiling points?
- (a) Nothing
- (b) A Cox-type chart
- (c) Vapor pressures at the temperature in question.

7. Which of these items would you classify as falling into the category of overhead expenses:
- (a) Supervisors salaries
- (b) Insurance on labor
- (c) Plant guards
- (d) Qualified welders
- (e) Temporary maintenance on construction equipment
- (f) Accounting services

8. There is a widely diverse opinion on diameters of holes in sieve trays. Some like large holes (1/2 to 1 inch diameter) and others prefer small holes (generally 3/16 inch diameter). Which of the following is an advantage for the small hole viewpoint?
- (a) They are less susceptible to fouling.
- (b) They provide a fine, narrow range of operating stability.
- (c) They give a greater degree of mixing.
- (d) They are cheaper because they can be punched instead of drilled.

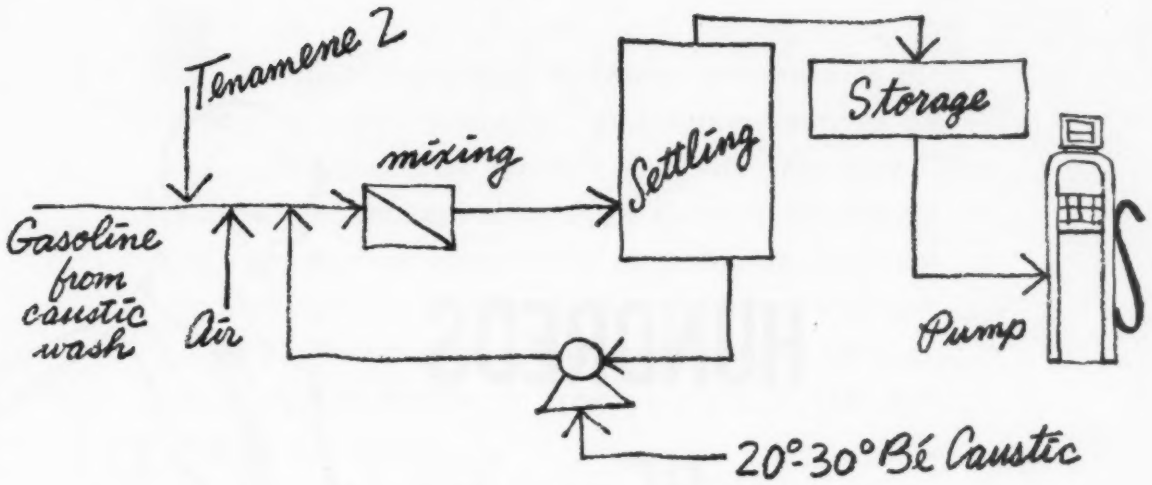
9. Trialkylamuminum compounds react with all organic compounds. True or False?

10. What is a disadvantage of an automatic gasoline blending system?
- (a) Higher initial capital investment.
- (b) Wider range of quality tolerance.
- (c) More laboratory analyses.

11. In the development of management personnel, an analysis of "personality traits" is not something upon which a development approach can be based. They can't be defined or measured, and only with great unpredictability and difficulty can they be changed. True or False?

12. With the new K charts, it is now possible to predict K values in the critical region. True or False?

Answers on Page 257



For gasoline stocks that respond, the economy and simplicity of Tenamene 2 inhibitor sweetening can seldom be equalled by any other treating method

In the presence of caustic and oxygen, Tenamene 2 catalyzes the conversion of mercaptans to disulfides. Being insoluble in caustic, it remains in the gasoline stream to effectively inhibit the formation of gum in the finished gasoline. Thus, it both sweetens and inhibits in essentially one operation.

Tenamene 2 inhibitor sweetening is primarily of interest to processors of catalytically-cracked gasoline. The response of such gasolines to the inhibitor sweetening method can be quickly determined by the following test:

1. Using sour gasoline from the primary caustic scrubber or mercaptan removal unit, put 700 ml. into each of several one-quart bottles.
2. To one group of samples, add Tenamene 2 at a rate of 5 pounds/1,000 bbls. (14.25 mg./liter). To another, add 10 pounds/1,000 bbls. (28.52 mg./liter).
3. Add 10 vol. % of 15° Baumé caustic to each sample.
4. Stopper the bottles, shake thoroughly. Replace stoppers with notched corks and store samples in a dark place at room temperature.
5. Examine at 3-hour intervals and determine the time required for sweetening.

If the results of this test indicate Tenamene 2 inhibitor sweetening to be effective in treating your sour gasoline, we will be glad to aid you in making a detailed study of your sweetening and stabilization requirements. In this study we will help you determine the optimum processing values for your particular operation, including inhibitor concentration, caustic strength and proportion, acid oil content, process temperature and reaction time. For an evaluation sample of Tenamene 2 and more information on the Tenamene 2 inhibitor sweetening method, write or call your Eastman representative, or write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Basic Procedure for Tenamene 2 Inhibitor Sweetening
(see sketch)

The sour gasoline is washed with 10-15° Baumé caustic. Between 5 and 15 pounds of Tenamene 2 is added per 1000 barrels of hydrocarbon. A small quantity of air is injected into the stream and the gasoline contacted with 20°-30° Baumé caustic. The gasoline is allowed to settle, then pumped to storage. If not already sweet when it goes to storage, the gasoline should sweeten within a few hours after storage.

Tenamene 2 inhibitor sweetening is, in almost every instance, more economical than doctor or copper chloride sweetening. Unlike doctor treating, no regeneration step is necessary, and there is no reduction in tetraethyl lead response. Unlike copper chloride treating, Tenamene 2 inhibitor sweetening does not allow the possibility of gum-catalyzing, copper contamination.

Most refineries find that minor modification of existing procedures enables them to adopt this method.

Tenamene 2
an Eastman gasoline additive

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; Atlanta; Boston; Chicago; Cincinnati; Cleveland; Detroit; Greensboro, North Carolina; Houston; Kansas City, Missouri; New York City; Philadelphia; St. Louis. **West Coast: Wilson & Geo. Meyer & Company,** San Francisco; Denver; Los Angeles; Phoenix; Salt Lake City; Seattle.

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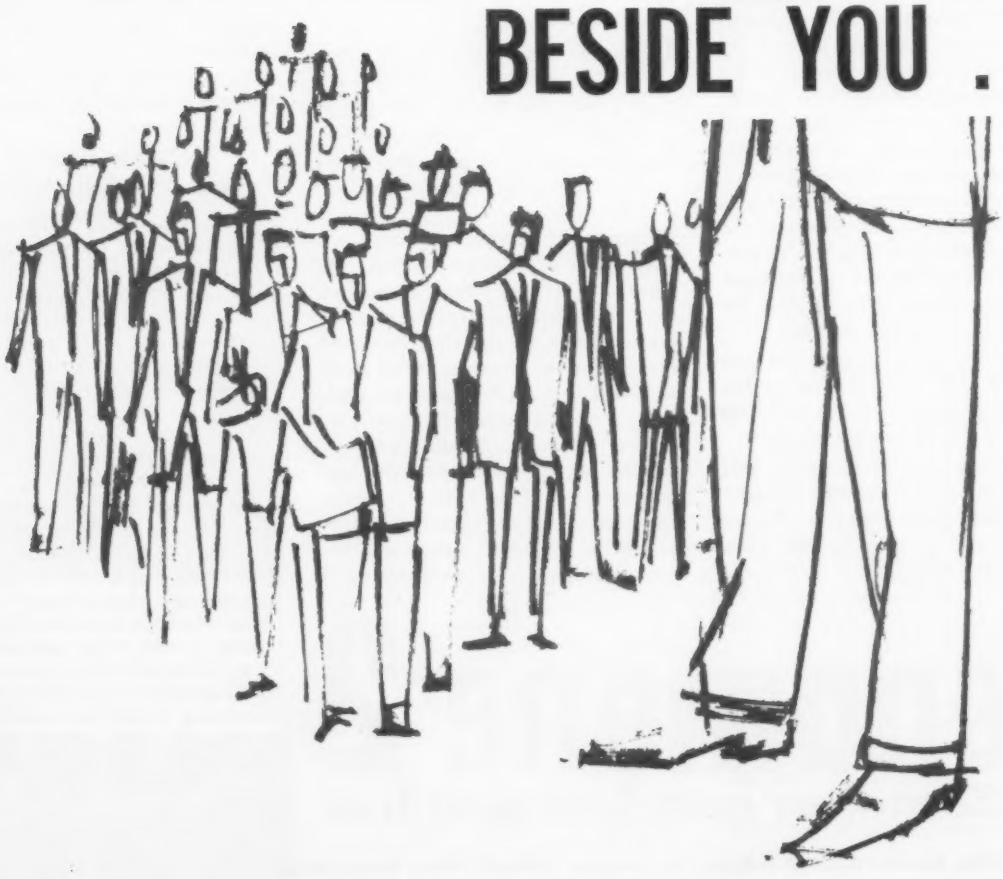

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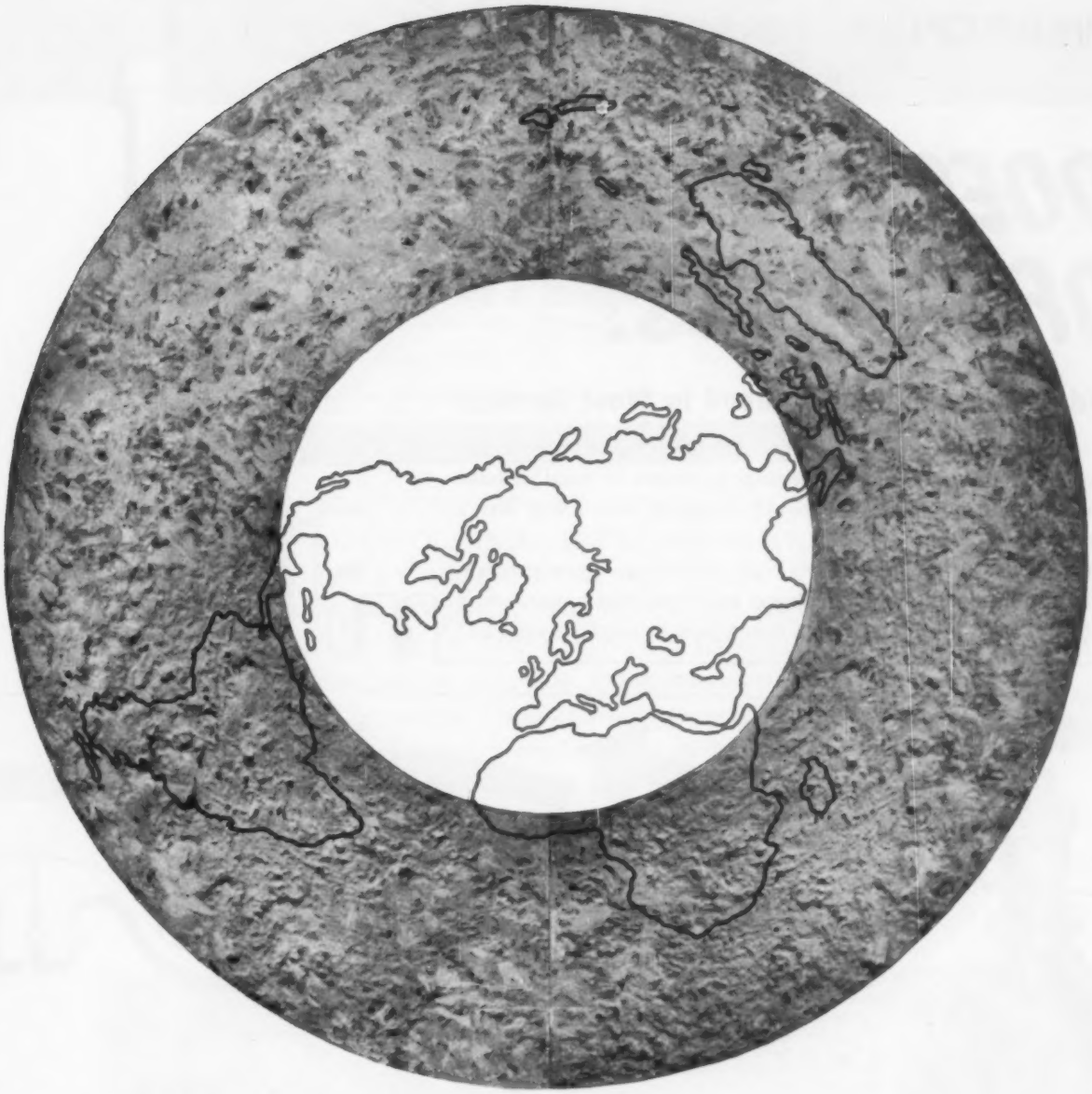

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—and to the same specification

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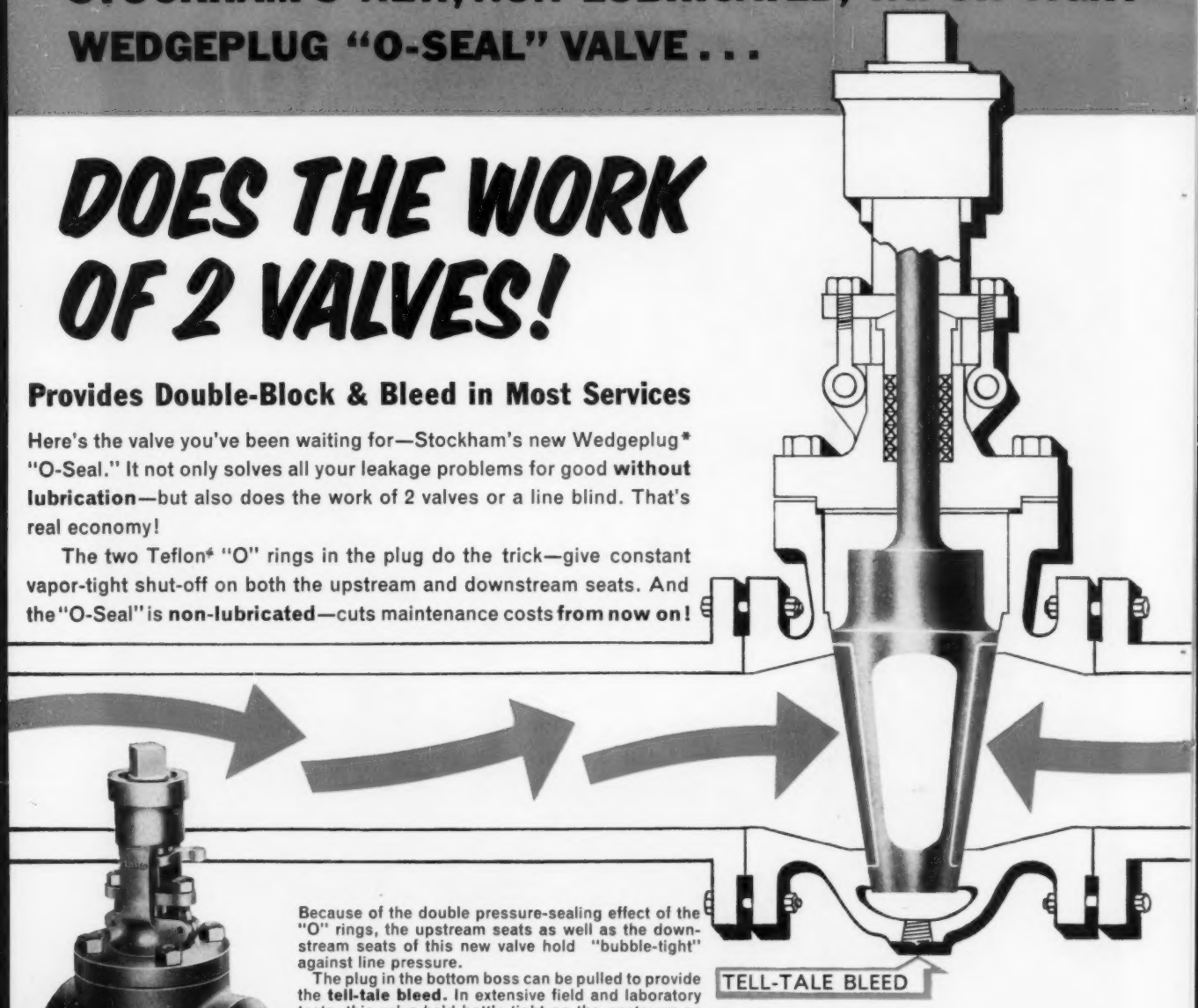
STOCKHAM'S NEW, NON-LUBRICATED, VAPOR-TIGHT WEDGEPLUG "O-SEAL" VALVE . . .

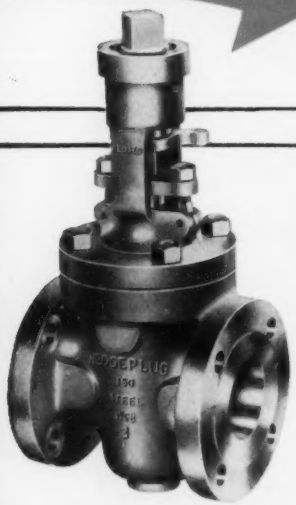
DOES THE WORK OF 2 VALVES!

Provides Double-Block & Bleed in Most Services

Here's the valve you've been waiting for—Stockham's new Wedgeplug* "O-Seal." It not only solves all your leakage problems for good **without lubrication**—but also does the work of 2 valves or a line blind. That's real economy!

The two Teflon* "O" rings in the plug do the trick—give constant vapor-tight shut-off on both the upstream and downstream seats. And the "O-Seal" is **non-lubricated**—cuts maintenance costs **from now on!**





Because of the double pressure-sealing effect of the "O" rings, the upstream seats as well as the downstream seats of this new valve hold "bubble-tight" against line pressure.

The plug in the bottom boss can be pulled to provide the **tell-tale bleed.** In extensive field and laboratory tests, this valve held bottle-tight on the upstream as well as the downstream seats when the bottom plug was removed. There is absolutely no mixing of products in manifolds.

Thus the "O-Seal" can do the job of two ordinary valves or a line blind in most services.

Your Stockham representative will advise you about the recommended services for the "O-Seal's" double-block and bleed feature.

OTHER OUTSTANDING ADVANTAGES — **Non-Lubricated—no costly maintenance necessary • Absolute shut-off that remains permanently "bubble tight" • Quick, easy operation—won't stick—ever • Double Seating for Double Safety—Ground metal-to-metal seat provides shut-off in case fire burns out "O" rings • No Product Contamination-Protected Seats.**

STOCKHAM'S NEW WEDGEPLUG "O-SEAL" VALVE

Call your STOCKHAM Distributor or Sales Representative for complete details, or write today for the new brochure on the Wedgeplug "O-Seal."

Stockham makes a *better* valve...for *every* job

WEDGEPLUG VALVE COMPANY *Division of* → **STOCKHAM VALVES *and* FITTINGS**

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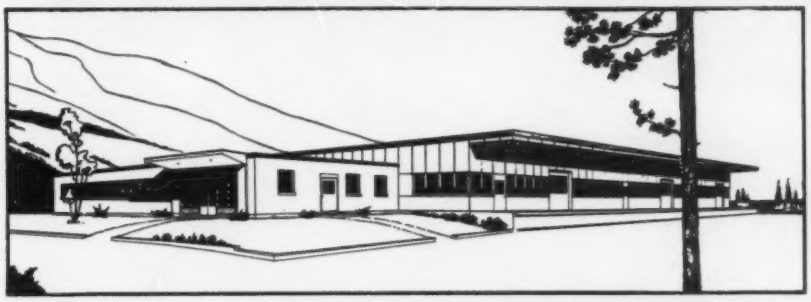

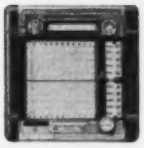

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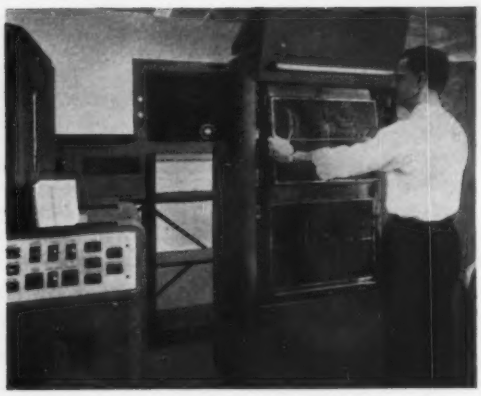

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CRANE

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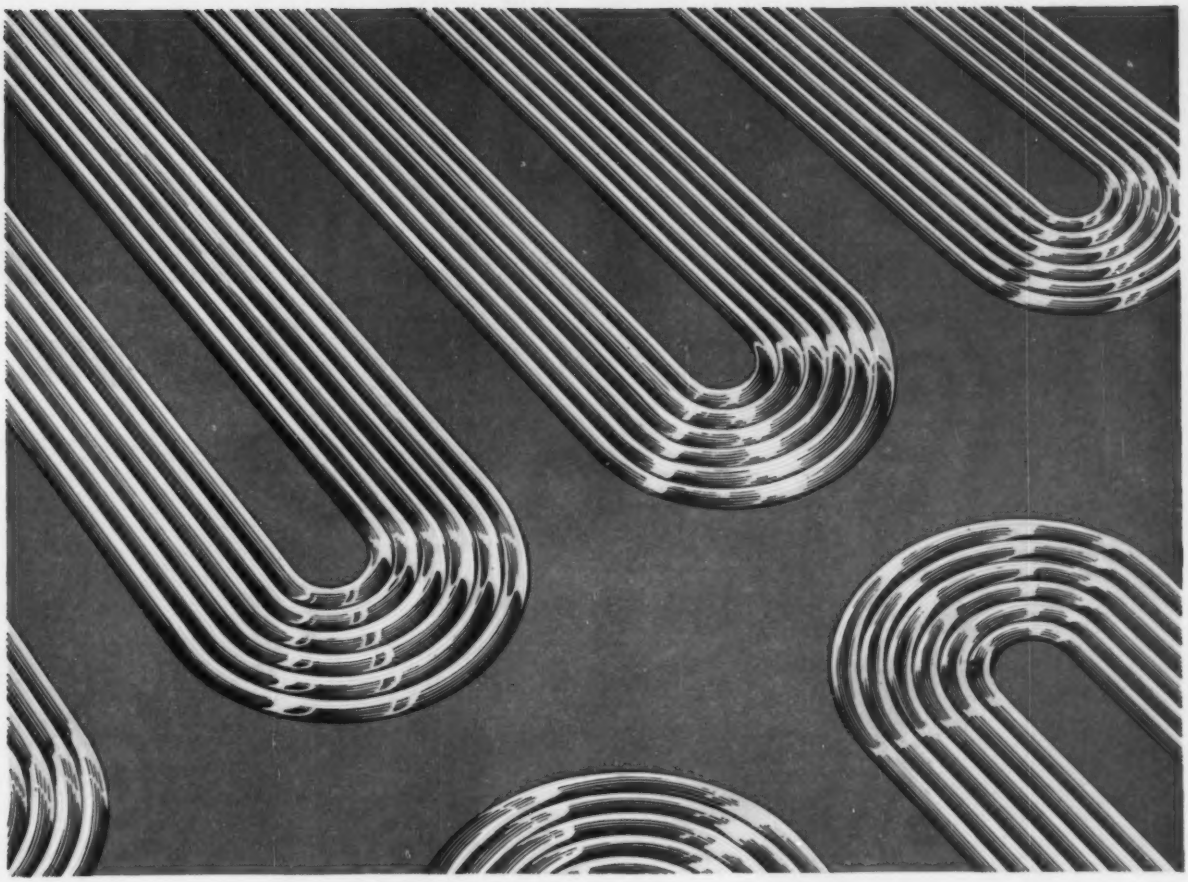
INSTRUMENTAL IN YOUR FUTURE 25 YEARS 1935-1960

It's a Fact: **A Beckman Infrared Analyzer has successfully controlled heat input to a refining tower for three years, maximizing ethylene recovery and minimizing methane content by analysis of the bottoms of a demethanizing absorber.**



NOW! U-BEND HEAT EXCHANGER TUBES BY CHASE

save time, trouble, money . . . all these ways!

SAVE on installation costs by eliminating one tube sheet . . . halving welding or rolling-in operations.

SAVE because handling is minimized.

SAVE time, labor and equipment used to fabricate U-bend tube on the job site.

SAVE because U-bend eliminates need for floating heads by handling differential expansions.

SAVE by eliminating scrap. Tubes fabricated to specifications do away with waste-end scrap.

SAVE because pallet loading insures storage economy.

Now you can order *pre-fabricated* tubes from Chase. That means you can realize the many on-the-job advantages of U-Bend tube, and at the same time be sure of *quality*.

Chase tube is manufactured under constant production control. Relief annealing immediately after bending avoids possible stress-failure later; precision hydrostatic testing of bends detects any possible hidden defects.

Chase U-Bend tube is available in uniform gauge, as well as with thickened center. Sizes range from ⅝" o.d. to 1" o.d., bent on radii from ⅞" to 25" depending on your requirements.

When ordering, be sure to include the following information: O.D. and I.D. in inches; wall thickness; length; quantity; alloy or material; temper; bend radius; length of thickened portion on dual-gauge tubes. Talk your specific needs over today with your nearest Chase office, or write Chase at Waterbury 20, Connecticut.

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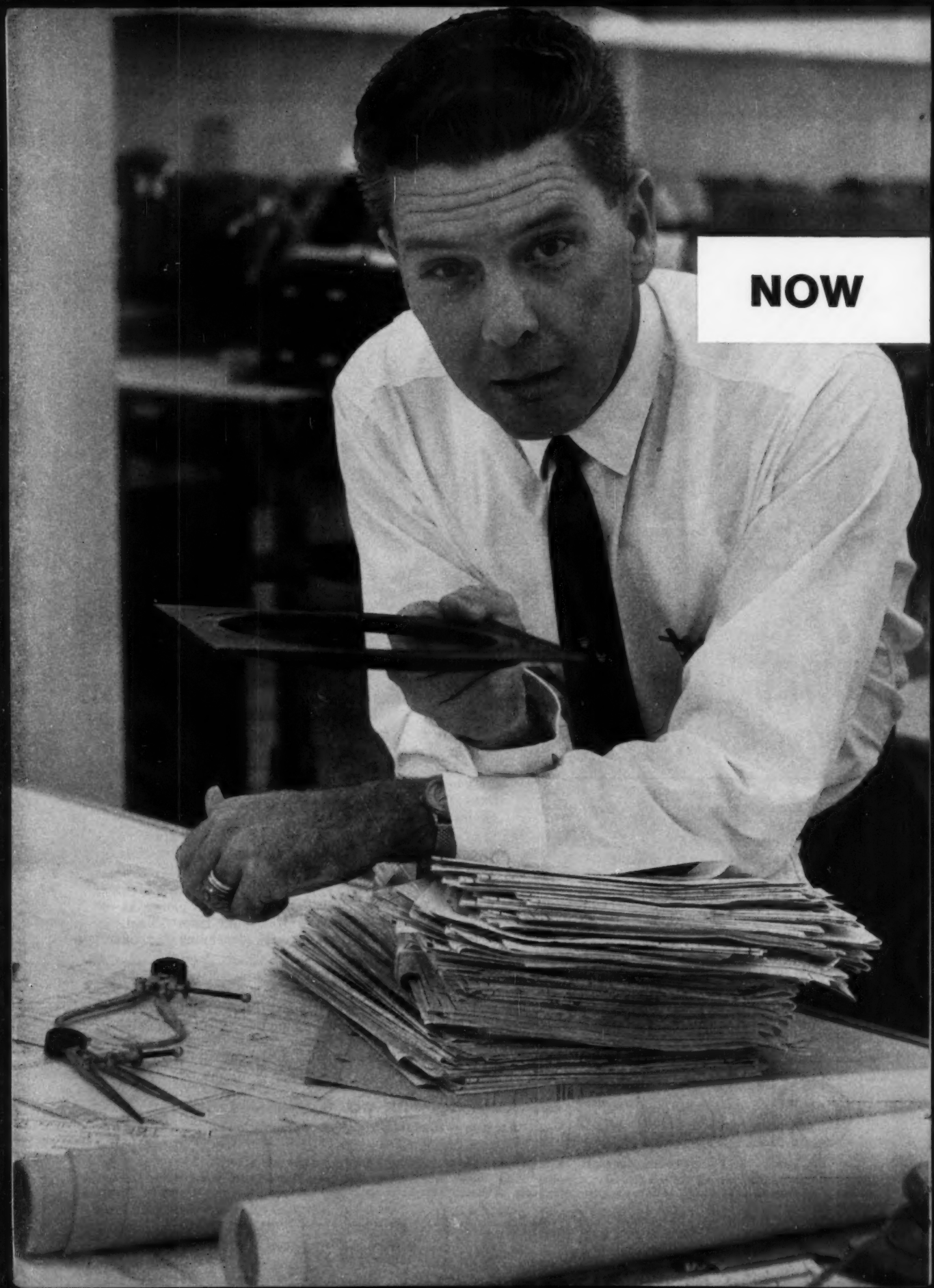
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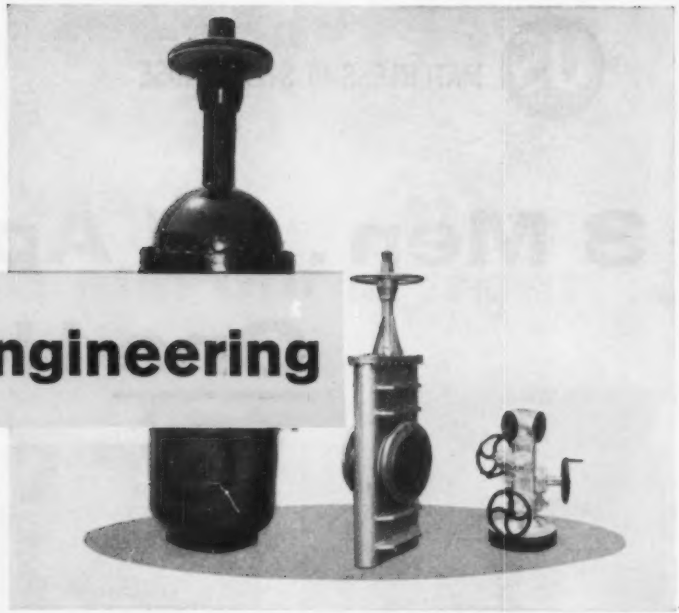

Left to right above, W-K-M's new: *Safe-T-Seal* Gate Valve (ASA); Pressure Sealing Gate Valve (ASA); Cross-type Triple Gate Valve (API).

112 IDEAS FOR THIS ONE W-K-M PART

New valves are being developed to outperform any you've ever known

From 112 designs by W-K-M engineers came an unusual valve seat. It is the secret of performance in W-K-M's new Pressure Sealing Gate Valve . . . and a hint of things to come.

Under wraps in W-K-M's Research and Development Laboratory are experimental valves looking like none you've ever seen . . . prototypes being tortured to simulate a lifetime of hard service. And, in restricted field installations, new models with no marking or identification, are making their final test runs.

W-K-M's exhaustive research and development program is a vital part of TOTAL Valve Engineering—W-K-M's unique dedication to *all* phases of valve technology. From it come today's valves and valves of the future . . . designed to work better, last longer . . . on the world's toughest jobs.

W-K-M

DIVISION OF ACF INDUSTRIES
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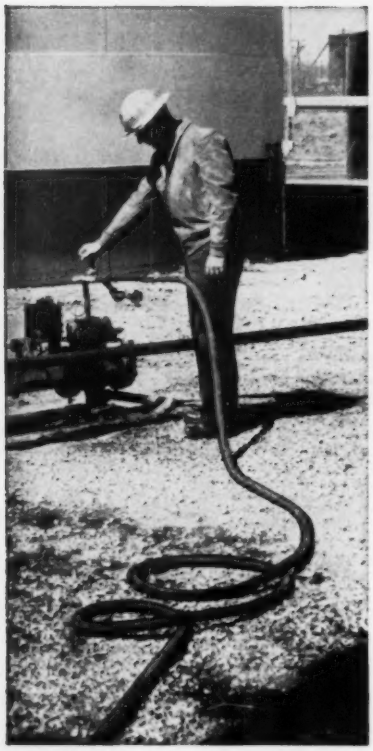
MATCHLESS #5 STEAM HOSE

3 Men . . . 3 Applications
One Hose



Safety
U. S. Matchless #5 Steam Hose has been used at a Phillips Petroleum refinery* since 1930, for thawing and firefighting.

Easy Handling
Here U. S. Matchless #5 is being used to remove spilled oil.

Economy
Warehouse boss at Phillips Petroleum inspecting a length of U. S. Rubber Matchless #5 Steam Hose.

Men like to work with U. S. Matchless® #5 because it's so lightweight, so flexible. Ordinary hose is hard to handle, can't take much dragging around. But the hose that's readily available, lasts longer, and satisfies the operators is the best investment. That's U. S. Matchless.

When you think of rubber, think of your "U. S." Distributor. He's the best on-the-spot source of technical aid, quick delivery, and industrial rubber products.

*Okmulgee, Okla.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

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Leader for 22 years

and still out in front . . .

For more than two decades UOP No. 5 Inhibitor has been leader of the most widely-used class of inhibitors—butyl phenylene diamine—the standard by which all other antioxidants are judged.

Introduced by Universal in 1938 as the first commercially used gasoline antioxidant of its type, UOP No. 5 was an instant success, was used by the Allied Forces in World War II in the bulk of their motor and aviation gasoline, and has since proved to be the most versatile inhibitor for catalytically cracked products, alkylates and catalytic reformates.

UOP No. 5 Inhibitor is used by refiners all over the world. So why take chances? Protect your gasoline, your customers and yourself with UOP No. 5.

UOP NO 5 INHIBITOR

* See our PSE*

Correct selection and most effective use of petroleum inhibitors and additives involves expert analysis and consideration of many factors relating to your feedstock and methods of processing. As specialists for over a quarter-century, UOP is able to provide unparalleled field service, brought to you by a member of our staff of Product Sales Engineers. For detailed information on the UOP family of superior inhibitors and additives, call or write our Products Department.

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company

"A ~~MAN~~ IS KNOWN BY THE customers it ~~COMPANY HE~~ KEEPS"

Repeat orders are a continual source of pride at Pacific. They indicate the success of our pumps in satisfying the needs of our customers.

Since 1923, Pacific Pumps Inc. has been supplying dependable centrifugal pumps to refineries, chemical plants and similar process installations. Thousands of Pacific process pumps are now contributing to plant efficiency throughout the world.

Pump design and manufacture are not the only features of this enviable performance record. Pacific has a skilled service engineering staff. These men are available when needed... anytime, anywhere.

For complete information about Pacific centrifugal pumps for process service, write to:

PACIFIC PUMPS

Inc... A Division of Dresser Industries, Inc.

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PACIFIC®

Offices in all Principal Cities

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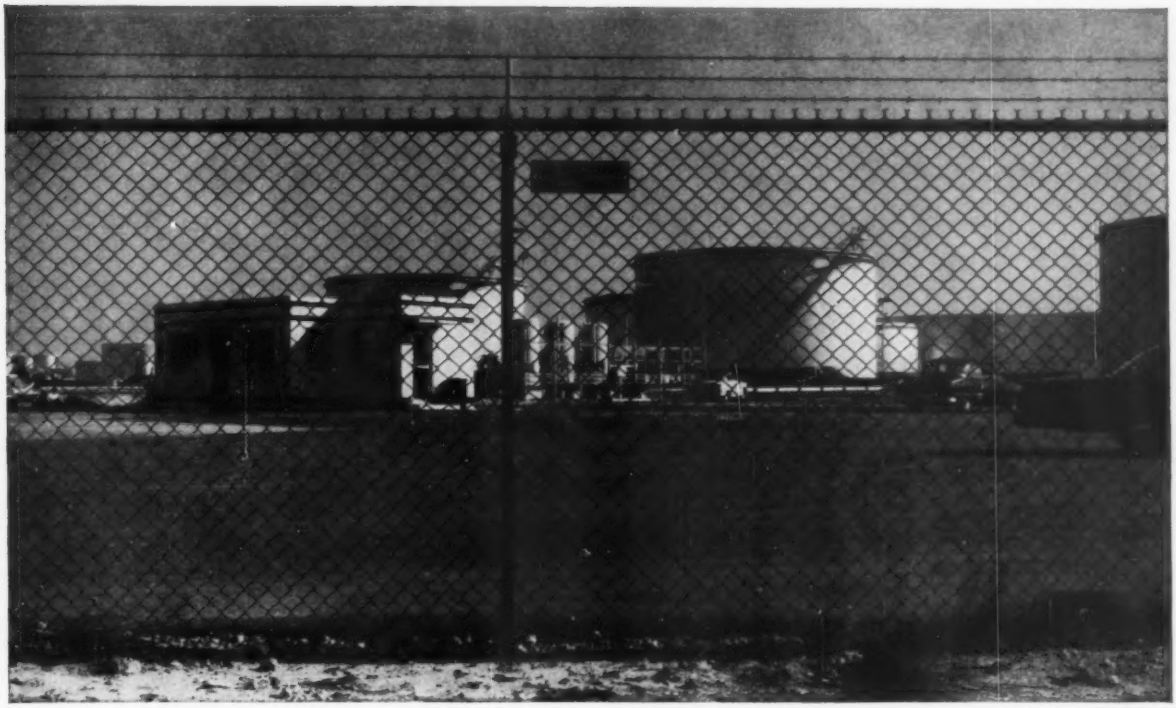
Specially engineered gates. Every Cyclone gate is just as sturdy, durable and non-climbable as the rest of the fence. They're mounted on heavy posts . . . equipped with solid hinges and catches . . . and have the closest precision in the locking device.



USS Cyclone Steel Fence keeps your private property private

Thieves, vandals and trespassers know better than to try getting past a USS Cyclone Steel Fence. This rugged, 24-hour watchman protects valuable property and equipment as no *human* watchman can. Cyclone also keeps children from playing on the premises . . . averts possible damage suits resulting from accidents. It's tough, strong, fire- and corrosion-resistant—built to stand indefinitely with very little maintenance. USS Cyclone Steel Fence will keep *your* private property private. Write to American Steel & Wire, Dept. 0243, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

USS and Cyclone are registered trademarks

Where security counts, count on USS Cyclone Fence

American Steel & Wire Division of United States Steel

Cyclone sales offices coast to coast

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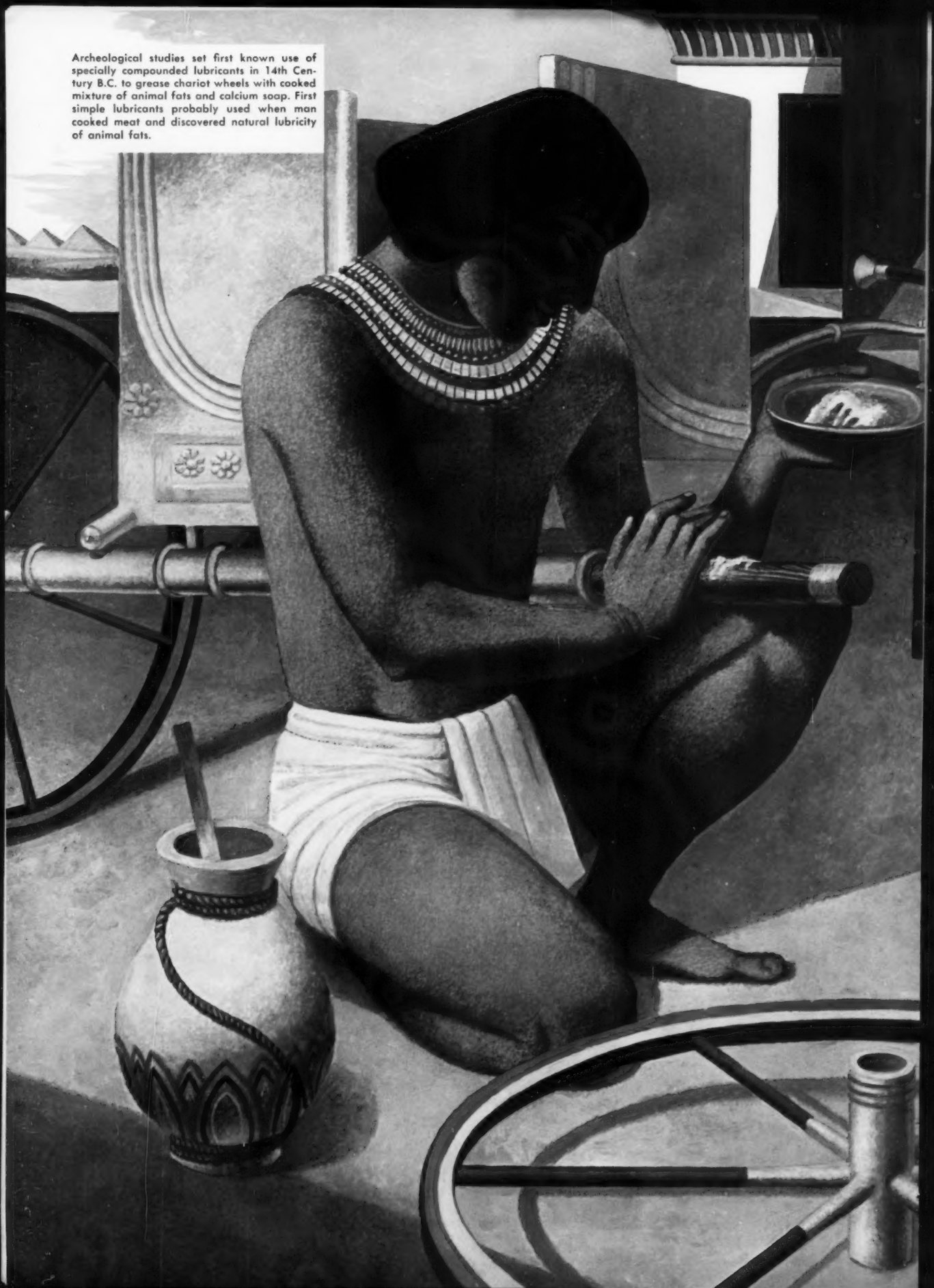


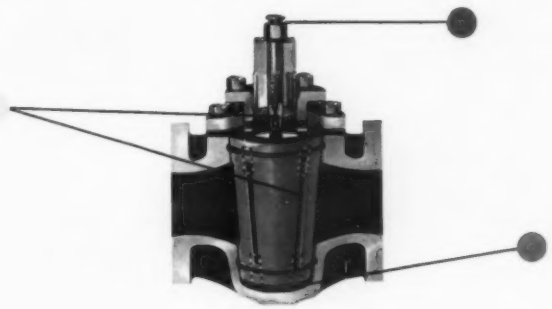
Archeological studies set first known use of specially compounded lubricants in 14th Century B.C. to grease chariot wheels with cooked mixture of animal fats and calcium soap. First simple lubricants probably used when man cooked meat and discovered natural lubricity of animal fats.

he greased the wheel of progress

. . . and his idea helped give you a better valve

One day about thirty centuries ago an ingenious charioteer silenced a squeaky chariot wheel with a handful of grease. To his surprise, the wheel not only ran quietly, but easier. Man had learned that lubrication makes things work better . . . and last longer.

Lubrication in Rockwell-Nordstrom lubricated plug valves does more than make them close easier and far outlast non-lubricated valves. *Pressurized* lubrication also hydraulically jacks the plug minutely from its seat, insuring easy operation and also maintaining a powerful seal against leakage around the plug . . . a seal that is instantly replaceable and can't be "worn out" like exposed metal-to-metal seats. For just a few of the reasons why you'll get better flow control at far lower cost with Rockwell-Nordstrom lubricated plug valves, examine the illustration below.



HOW LUBRICATION MAKES A BETTER VALVE

- Lubricant quickly, easily injected through Rockwell fitting.
- Lubricant travels through Sealdport® system to create powerful seals against leakage and prevent metal-to-metal wear between plug and body . . . note seats never exposed to the line.
- Lubricant hydraulically jacks plug minutely from seat for instant quarter-turn operation.

Rockwell-Nordstrom is the original and world's most complete line of lubricated plug valves. Available in sizes from ½" to 36" and pressures to 15,000 lb. For additional information, see your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania. Canadian Valve Licensee: Peacock Brothers Limited. If you live outside the USA, write: Rockwell International S.A., Geneva, Switzerland.

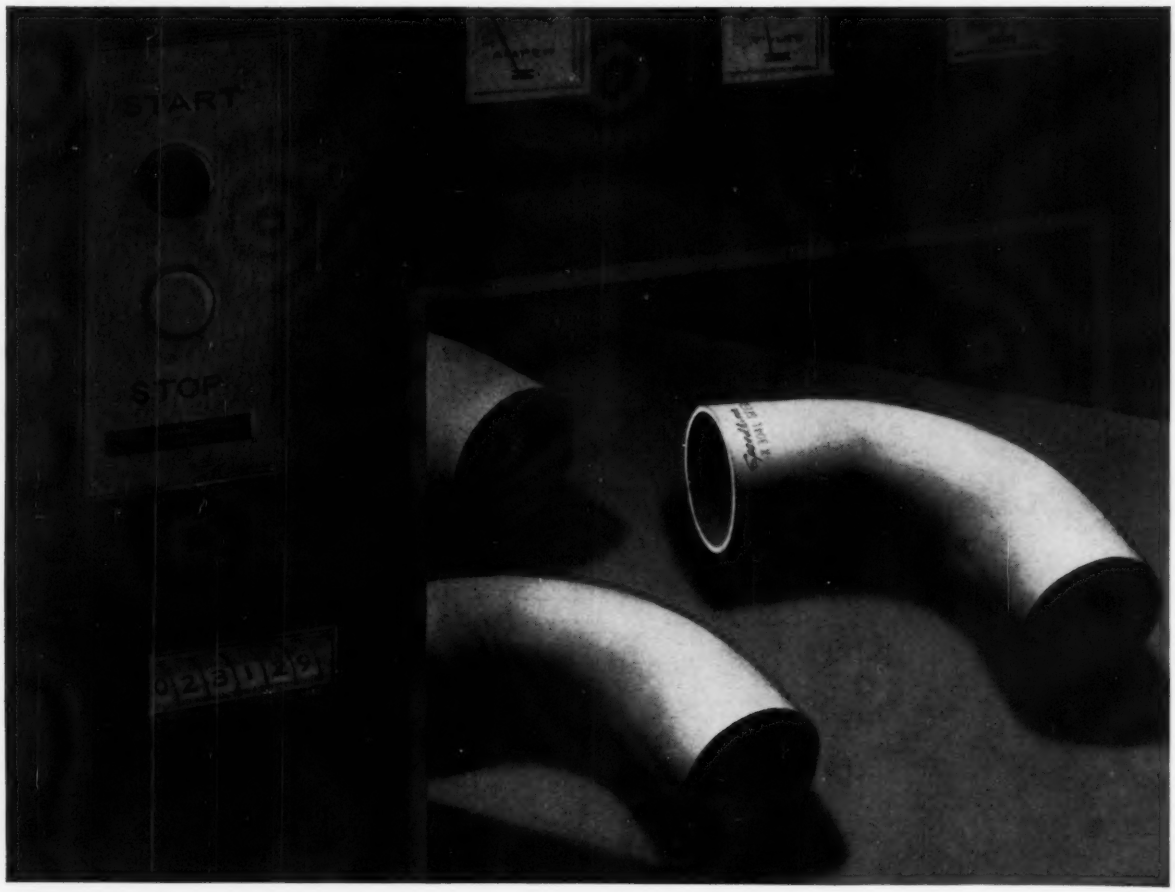
Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

THERE IS A DIFFERENCE IN PIPE FITTINGS



Speedline® FITTINGS ARE MADE TO MEET CRITICAL STANDARDS

Now you can comply with the severest codes and save up to 50% on *critical* stainless steel process lines when you specify SPEEDLINE Fittings and economical light wall Schedule 5 or 10 pipe.

The new issue of Code for Pressure Piping ASA B31.3-1959, for example, allows a *design pressure* of 611 psi for 2″ ips Schedule 5, Type 304L process pipe at 100°F. Under the same conditions, allowable design pressure for 1½″ ips pipe would be 768 psi; for 1″ ips, 1122 psi.

Since SPEEDLINE Fittings have been specially designed for use with light wall pipe, they can result in substantial installation economies whether you plan to butt-weld, flange or socket-join your lines. Yet *long tangent* SPEEDLINE Fittings cost no more than other fittings which are suitable for "non-critical" service only.

Let a SPEEDLINE Distributor show you why there *is* a difference with SPEEDLINE Fittings... and what that difference can mean at your plant. Complete Catalog on request.

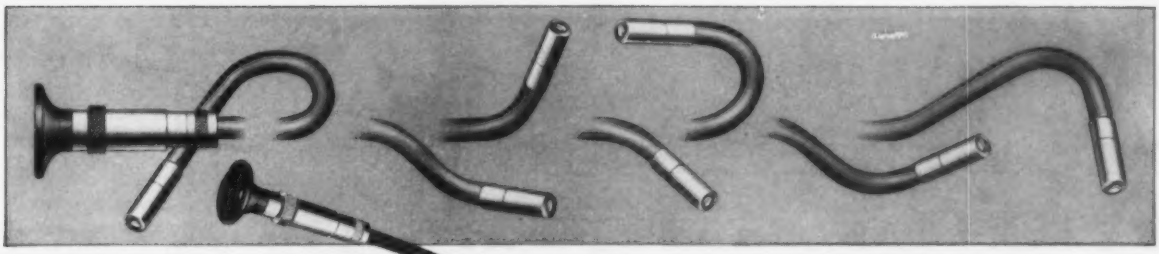
For Distributor Listings see pages 1513 to 1516 Chemical Engineering Catalog. 1005

Speedline®

CORROSION-RESISTANT FITTINGS

STAINLESS STEEL • ALUMINUM • SPECIAL ALLOYS

A PRODUCT OF **HORACE T. POTTS COMPANY** • 566 E. ERIE AVENUE • PHILADELPHIA 34, PENNSYLVANIA



Focusing eyepiece provides clear definition at various working lengths.

For the ultimate in precision viewing of intricate, hard-to-reach areas . . .

A.C.M.I. Fiber Optic *Flexible* Borescopes

FOR visualization in inaccessible curved areas where a flexible instrument capable of adapting itself to irregular contours is required.

Fiber Optic Borescopes are equipped with focusing eyepiece and fixed or movable objective as required. Illumination can be provided by a flexible fiber optic light carrier with an external light source or an annular fiber optic light carrier attached to the image carrier. Fiber optic light carriers are particularly advantageous for transmission of intense cold light to inaccessible or hazardous areas.

Please send details and sketch of your requirements.

AMERICAN CYSTOSCOPE MAKERS, Inc.

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Babbitt *Adjustable* **SPROCKET RIM**
with Chain Guide
CHANGES THAT DANGER ZONE TO A SAFETY ZONE

. . . cuts costs when you SIMPLIFY PIPE LAYOUT

When you modernize to make money, go all the way. Cut piping costs to minimum with planned simplification. Give your staff a free hand to effect economics—at the same time, convert Danger Zones to Safety Zones. Equip every overhead valve wheel in your plant with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. Just phone your mill supply salesman, or contact us direct.

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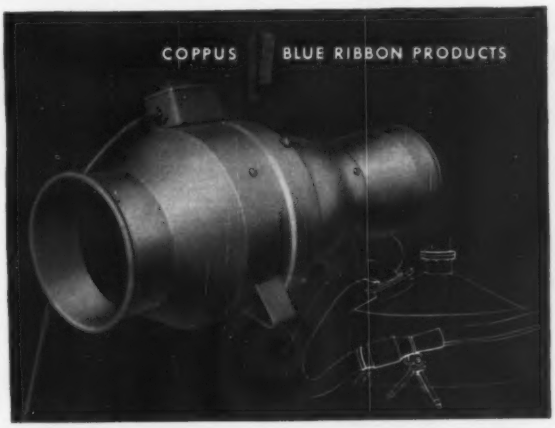
6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.



COPPUS "Blue Ribbon" Ventilator-Exhausters are portable and easily adaptable . . . for exhausting welding fumes or foul air from enclosed vessels. Mail coupon below for facts.

COPPUS ENGINEERING CORP.
418 Park Avenue, Worcester 10, Mass.

- ☐ in tanks, tank cars
- ☐ in underground manholes
- ☐ for exhausting welding fumes
- ☐ on boiler repair jobs
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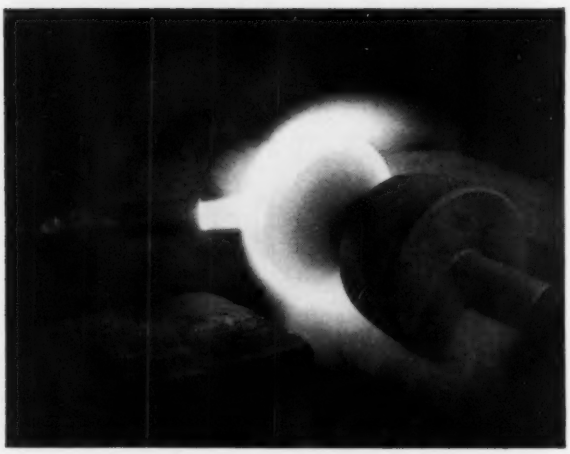
COPPUS BLOWERS

MODERNISED HARDFACING...

Spraying "Stellite" powder onto a parabolic valve.



Fusing the "Stellite" deposit with an oxy-acetylene torch.

By means of the Spray-Fuse process Deloro Stellite cobalt base powder alloys can be deposited to protect components subjected to onerous conditions of heat, abrasion and corrosion. The powder is applied by conventional powder guns followed by fusion to the base metal with an oxy-acetylene torch. The overlay is effectively anchored and is no longer a mechanical bond as with normal metal spraying. The surface left is smooth, thus minimising any subsequent grinding.

The process is ideally suited for the hardfacing of components with a thin deposit of "Stellite", as it is **simple, economical** and **fast.**

Send for publication B.39

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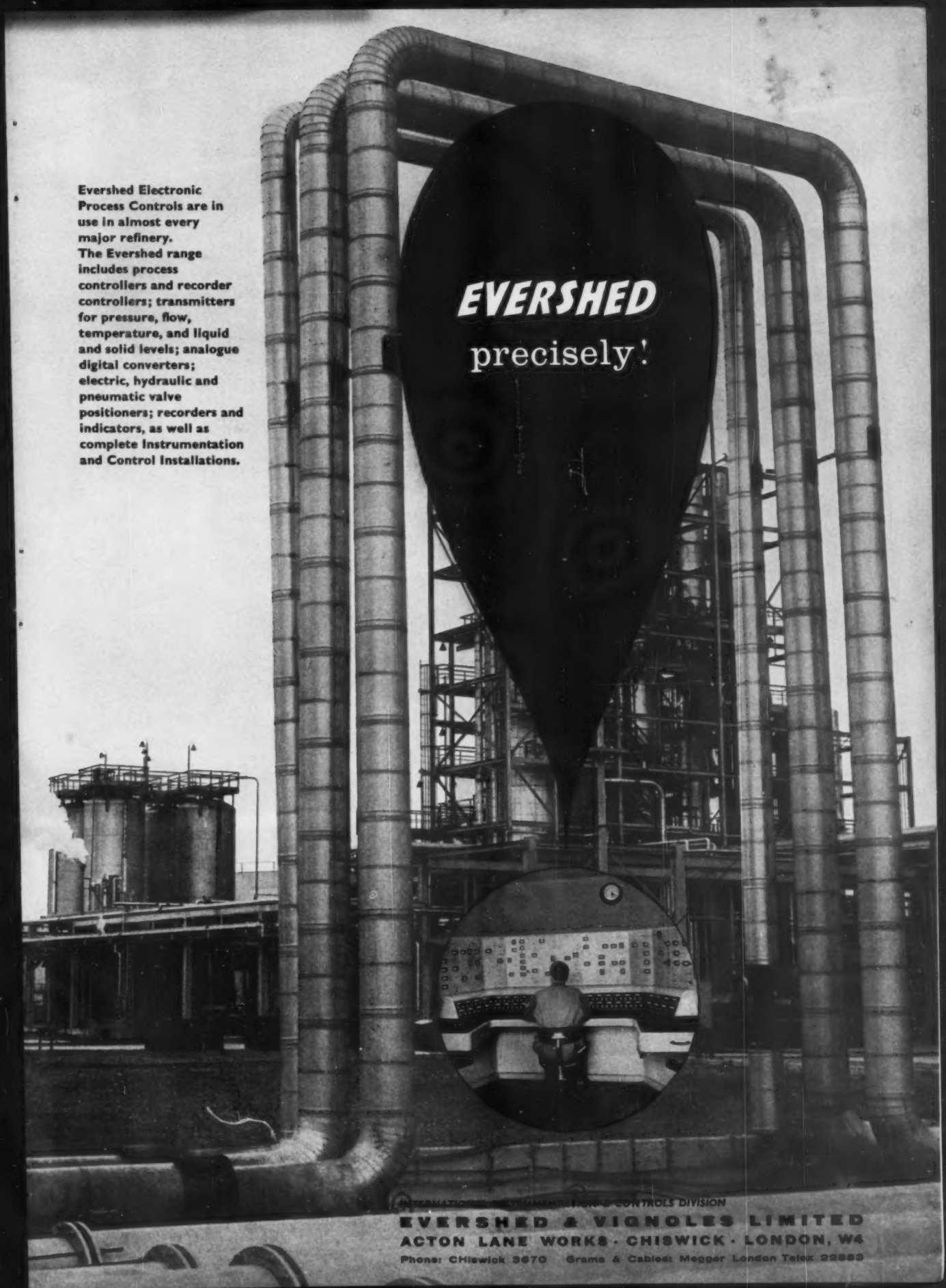
DELORO STELLITE DIV. OF DELORO SMELTING & REFINING CO. LTD. BELLEVILLE · ONTARIO · CANADA

AD. NO. 317


EVERSHED
precisely!
Eversheds Electronic Process Controls are in use in almost every major refinery.
The Eversheds range includes process controllers and recorder controllers; transmitters for pressure, flow, temperature, and liquid and solid levels; analogue digital converters; electric, hydraulic and pneumatic valve positioners; recorders and indicators, as well as complete Instrumentation and Control Installations.
INTERNATIONAL INSTRUMENTS FLOW & CONTROLS DIVISION
EVERSHED & VIGNOLES LIMITED
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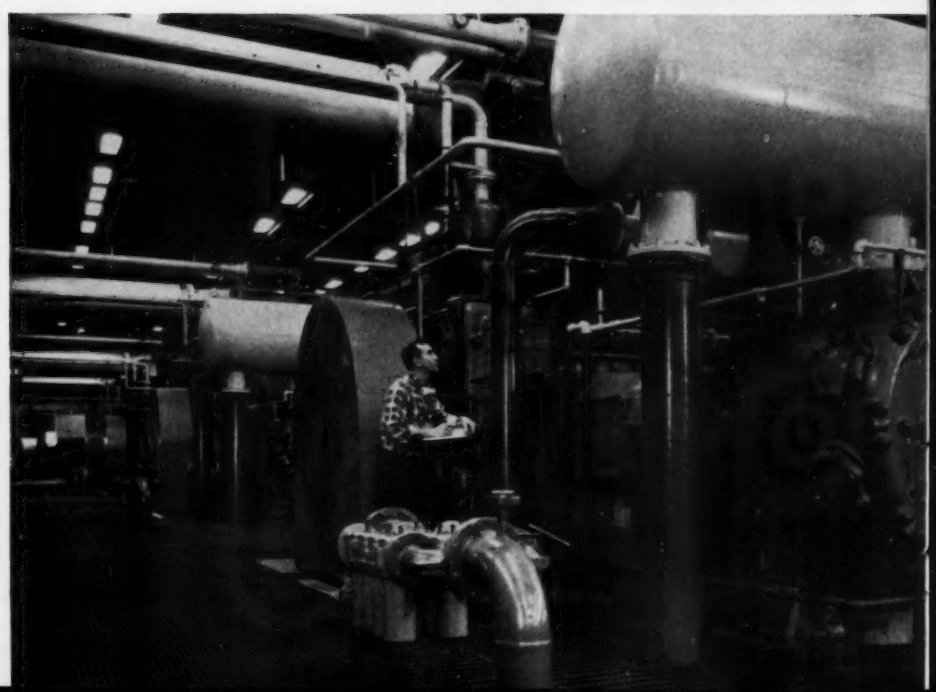
Cooper-Bessemer compressor shown is one of two units for compression of synthesis gas.



View showing the four Cooper-Bessemer compressors. Unit in foreground is for "mixed gases" (air, nitrogen and methane).

Henry LaRue, *Ammonia Area Superintendent, Spencer Chemical Company, Vicksburg, Mississippi explains...*

How we compress four different gases with a team of four Cooper-Bessemer compressors

"Our entire ammonia plant depends on the uninterrupted flow of component gases, compressed by four Cooper-Bessemer GMW-8 Compressors," reports Mr. LaRue. "These four 2000 hp gas engine driven units have been the heart of our system 24-hours a day, day in and day out, since 1953.

"Two of the compressors, with five cylinders each, compress three different gases... air, nitrogen and methane. The other pair of compressors pump a synthesis gas mixture of hydrogen and nitrogen.

"Despite their 'round-the-clock operation for seven years, none of these Cooper-Bessemer compressors has had a major down-time for maintenance. They represent a sound investment."

Cooper-Bessemer engineers are at your service to help you plan compression and power facilities. Call the nearest office.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester • Pittsburgh
Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport • Houston
Greggton • Dallas • Odessa • Pampa • Casper • Seattle • San Francisco • Los Angeles
SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd.... Edmonton • Calgary • Toronto
Halifax • Stratford
C-B Southern, Inc.... Houston
Cooper-Bessemer International Corp.... New York • Caracas • Anaco
Cooper-Bessemer, S.A.... Chur, Switzerland • The Hague, Netherlands • Mexico City
The Rotor Tool Company... Cleveland

Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL,
ENGINE, TURBINE OR MOTOR DRIVEN

*Completely adjustable**

Flooded Disc Scrubber Removes Sub-Micron Fumes

The Research-Cottrell high efficiency scrubber uses the unique flooded disc principle for removing sub-micron fumes in steel-making furnaces and chemical processing.

As shown in the illustration, the outstanding feature of this scrubber is the simple, adjustable "flooded disc." The flooded disc adjusts for maximum cleaning efficiency over a wide range of operating conditions.

* *Automatic positioner immediately adjusts the disc to meet your varying gas and dust control problems.*

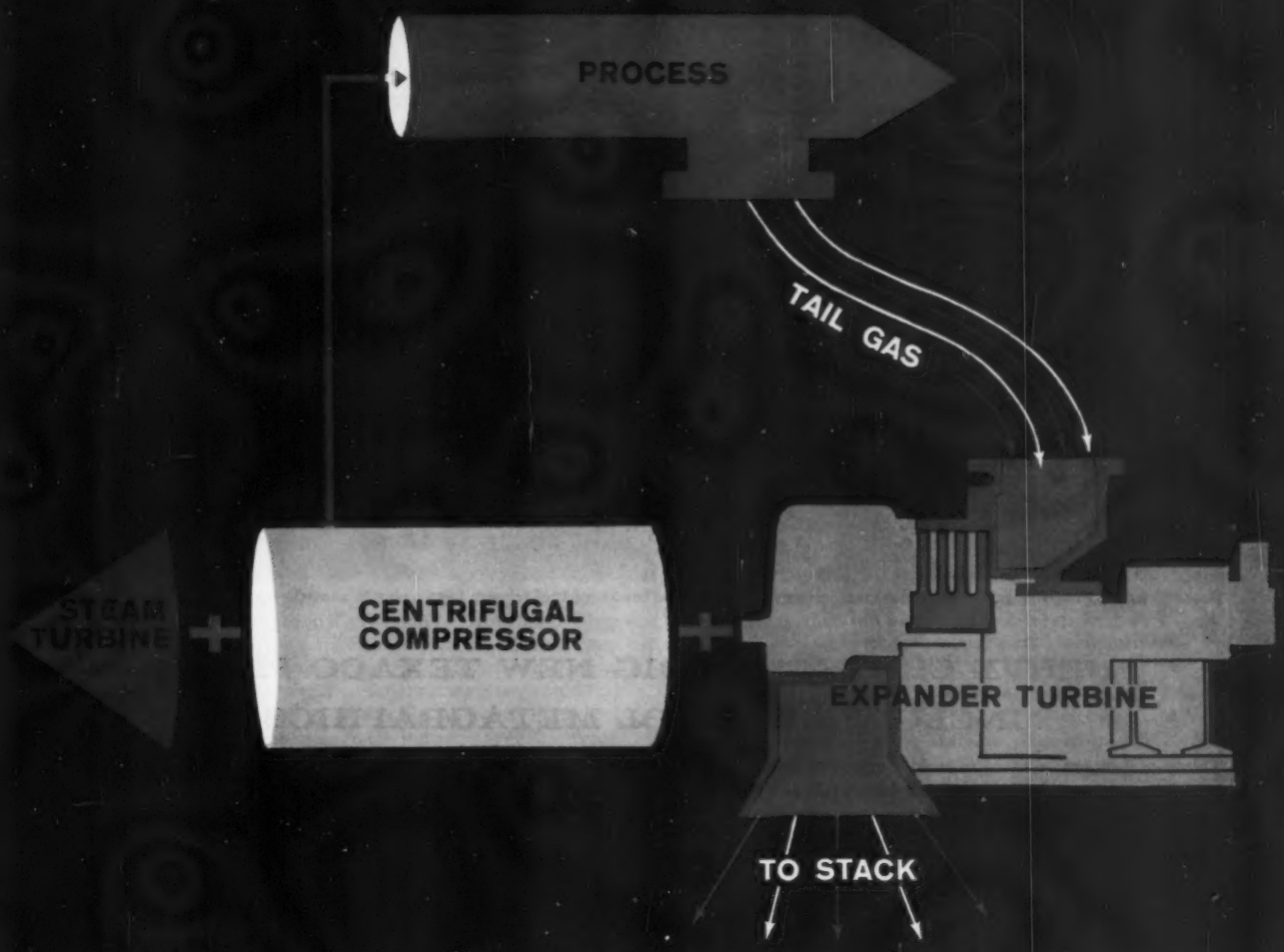
Research-Cottrell, with over 48 years of industrial gas cleaning experience, will be glad to consult with you on any specific problem.

For further information, write for Bulletin 110.

Research-Cottrell

RESEARCH-COTTRELL, INC., Main Office and Plant: Bound Brook, N. J.
Representatives in principal cities of U.S. and Canada

RESEARCH COTTRELL INC. TRADE MARK RC807



TAIL GAS WAGS PROCESS, SAVES ⅔'s POWER COSTS

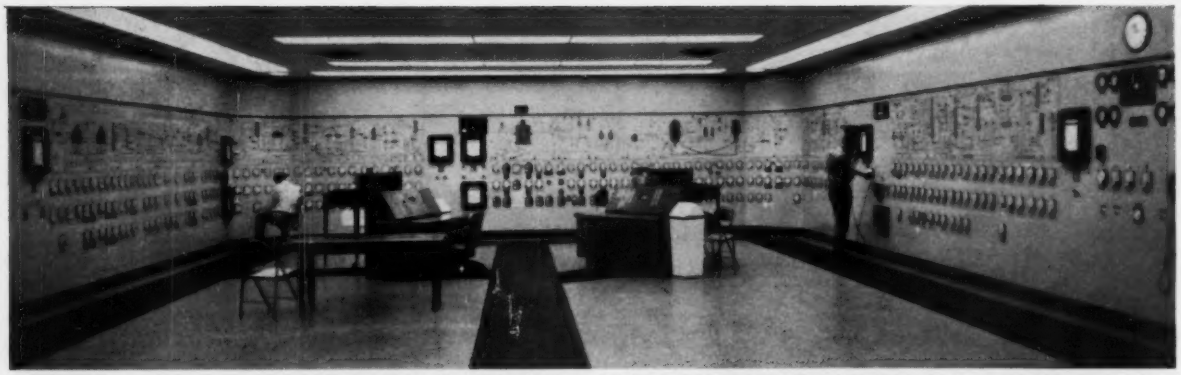
In less serious moments we call it "tail-wagging." Actually, it's the art of taking substantial amounts of power from process exhaust or "tail" gases. By making the tail wag the dog . . . putting this power back into the process . . . major increases in efficiency can be obtained.

The key machine is the turbine gas expander that returns power to the process by serving as a prime mover. In one process, for example, a centrifugal compressor delivers air to the process. After reaction, in which the oxygen is removed, the residue or "tail" gas leaves the process at extremely high temperatures and under pressure. Passed through a turbine expander, this gas does useful work.

This work can be applied to driving generators, blowers or geared to reciprocating equipment. If used driving a centrifugal compressor, it can supply as high as 85% of the driving power. An auxiliary motor or steam turbine can provide the make-up and start-up power.

Recent developments in design, materials and manufacture have now made "tail-wagging" with high horsepower, high temperature turbine gas expanders possible for a variety of processes. At Worthington we have answers you need to make a complete study of this new opportunity for process plant economy. For information about "tail-wagging" (turbine gas expanders and their application) please write Worthington Corporation, Expander Section (48-10), Wellsville, New York.

WORTHINGTON



Bristol Metagraphic recorders and indicators occupy lower three rows on panel (shown in two photos above).

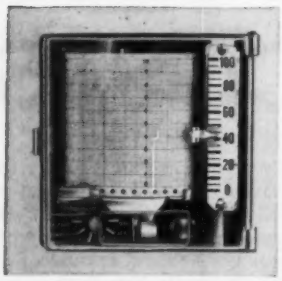
"NERVE CENTER" AT BIG NEW TEXACO PLANT INCLUDES BRISTOL METAGRAPHICS

This model central control room is the nerve center for a vast petroleum processing complex. It's located in the new Puget Sound Works of Texaco Inc., at Anacortes, Washington.

A key feature of the control system is a battery of several hundred Bristol Metagraphic pneumatic recorders, indicators, and controllers (lower three instrument rows on panel). The new plant produces motor gasolines, jet fuels, liquefied petroleum gases (LPG), diesel fuel, furnace oil, and heavy fuel oil. Crude oil capacity is 45,000 barrels per calendar day.

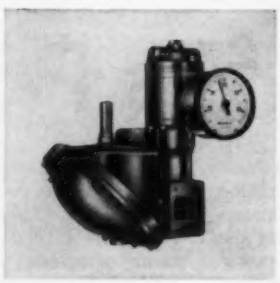
This is just one of hundreds of installations of Bristol Metagraphic instruments in use today in processing plants throughout the country. These compact instruments are ideal for graphic panel use, or where true "plug-in" versatility is necessary to insure maximum control system reliability and continuity of service. We'll be glad to send you the complete Metagraphic story. O.34

...and behind every panel, precision

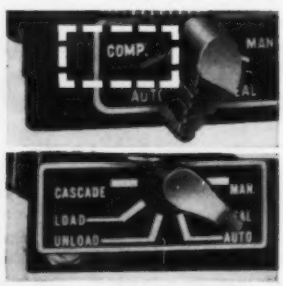


Metagraphic Recording Receiver... plugs and unplugs in 5 seconds. More than 36 pneumatic models, many electronic Dynamaster® potentiometer and bridge instruments — all with easy-to-read, human-engineered scales and charts.

Metagraphic Indicating Receiver... feature 9 inches of effective scale length, complete 10-second interchangeability with recorder of same type. Functionally colored pointers, plus long scale length makes distant reading easy.



Metagraphic Pneumatic Transmitters measure temperature, pressure, vacuum, absolute pressure, differential pressure, flow, liquid level or mechanical motion. Transmit on universal 3-15 psi pneumatic signal.



Pneumatic Control Stations allow utmost in operating flexibility. Four-position station (top) for computer-controlled refineries and chemical plants. Six-position station (bottom) for bumpless transfer in cascade systems. Many others available.

regardless of the nature of your measurement or control problem,

Bristol has matching miniature instruments for it

• Pneumatic transmission and control • Electronic potentiometers and bridges • Instruments for process computer systems • Electronic measurement—pneumatic transmission • Telemetering instruments • Recording gauges

Now, for the first time, you can get matching instruments for graphic panels, consoles, or other set-ups for all your process requirements—including electronic, pneumatic, telemetering, and gauge measurements. Bristol miniature instruments all have 5" x 5⅛" panel dimensions, fit 4 9/16" square cutout, and harmonize perfectly with each other.

Pneumatic Transmission. Bristol Pneumatic Metagraphic receivers operate on a universal 3-15 psi signal. They indicate or record *pressure, differential pressure, absolute pressure, liquid level, flow, temperature, mechanical motion and many other variables.* Indicators and recorders interchange on a full plug-in basis. There are 36 receivers, 38 controllers, and widest variety of transmitters in the industry to choose from.

Process Computer Control Instrumentation. Now available: two entirely new Metagraphic control stations, for use with process control computer systems.

Dynamaster* Electronic Potentiometers and Bridges, using same time-proven principles as full-size instruments, can provide measurements from such electrical sensing elements as thermocouples, strain gauges, pH electrodes, photoelectric cells, etc. Same high accuracy and reliability as full-size Dynamaster instruments.

Electronic Measurement—Pneumatic Transmission. The Miniature Dynamaster Electronic Potentiometer and Bridge Instruments, described above, are now available as pneumatic transmitters—3-15 psi signal. They will make any measurement that can be transduced to an electrical quantity and transmit that measurement pneumatically for Metagraphic recording, indicating, and automatic control.

Telemetering. Metameter* telemeter receivers, in 5" x 5⅛" case, can receive the same measurements from remote locations as their full-size counterparts. Can be installed miles from transmitter center.

Standard Pressure Gauges . . . now also offered in miniature-case, plug-in and non-plug-in types. Ranges from 0-3 through 0-100 psi.

For complete data, write The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

**T.M. Reg. U.S. Pat. Off.*

BRISTOL measurement and control

Series 663 Electronic Dynamaster potentiometer. Motor can drive almost any auxiliary devices—retransmitting slidewires, alarm contacts, analog-to-digital encoders. Available for electronic measurement—pneumatic transmission.

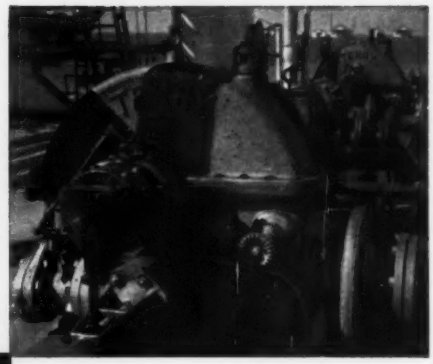
Metagraphic Pneumatic Controllers can plug in on receiver case, as shown here, or directly at controlled process. Proved force-balance operating principle requires almost no moving parts, nothing to wear out. 38 different models.

BRISTOL

for improved production through measurement and control

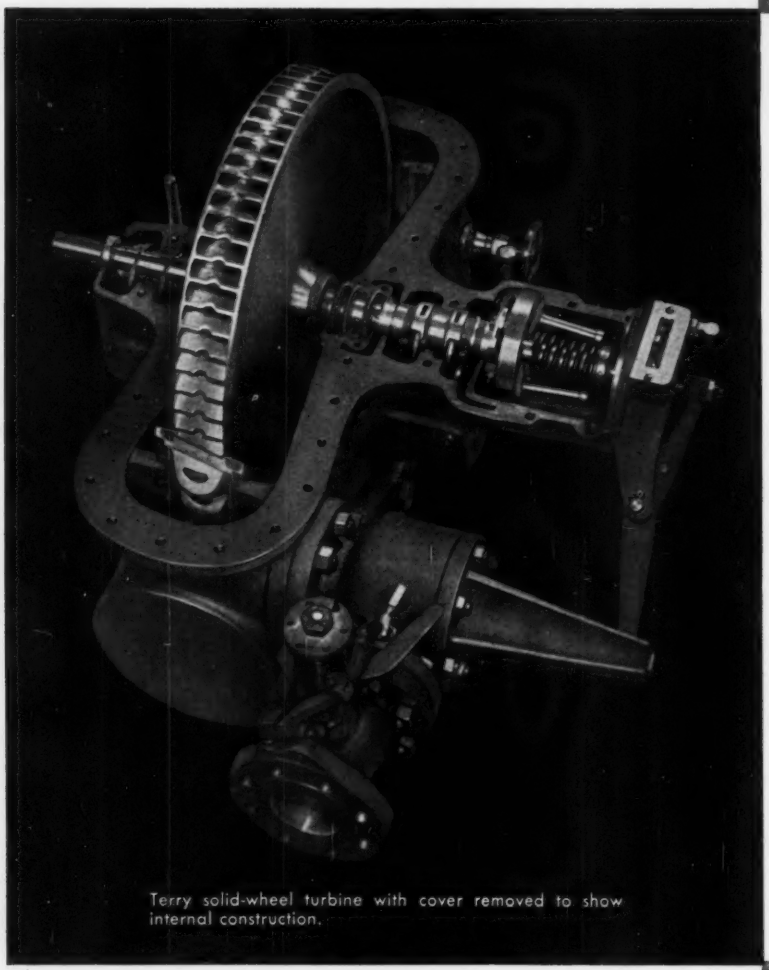
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.



TERRY SOLID-WHEEL TURBINE

spells service continuity for mechanical drives



Terry solid-wheel turbine with cover removed to show internal construction.

For mechanical-drive applications, such as these, you will never find the equal of Terry solid-wheel turbines for built-in dependability. They are *designed* for trouble-free operation under the toughest service requirements.

The wheel, for example, is a single forging of special composition steel. Unlike a built-up wheel, there are no separate parts to loosen or work out. The blades can't foul since they are double-rim protected...with one-inch clearances at either side.

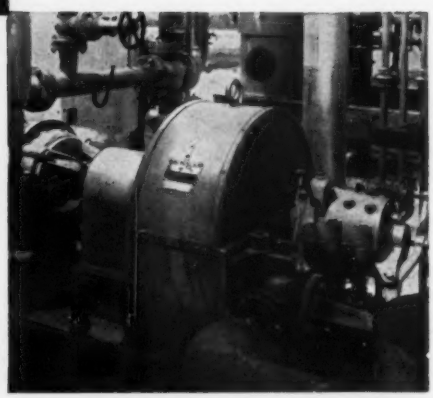
Any blade wear, which might occur after years of service, is of little consequence. As the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.

Specify Terry solid-wheel turbines for your next mechanical drives. They are available in capacities from 5 to 2,000 hp., speeds up to 10,000 rpm. Vertical turbines are built in sizes from 5 to 300 hp.

For full information about these reliable turbines, send for bulletin S-116.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY



TT-1216

For more data on advertised products, use Readers' Service Cards, last page.

Heating season ahead

Time to stabilize and improve your heating oils with FOA-2

No filter clogging. No nozzle plugging. No sludge.

These are qualities you can add to your heating oils, and at low cost, too. Result: a clean, hot, steady-burning fuel that wins added friends for your brand product.

You need only a few pounds of Du Pont Fuel Oil Additive No. 2—usually 5 to 15 pounds per 1,000 barrels—to do the job. This concentration has stabilized millions of barrels of heating and fuel oils since the introduction of Du Pont FOA-2 nine years ago.

FOA-2 solubilizes and disperses. Prevents sludge formation. Dissolves sludge which may already have formed. Reduces insoluble residue to such small particles that they flow and burn right along with the oil. *It stabilizes your product.*

Of course, FOA-2 is ashless—burns completely with the fuel, leaves no traces to foul the burner nozzle.

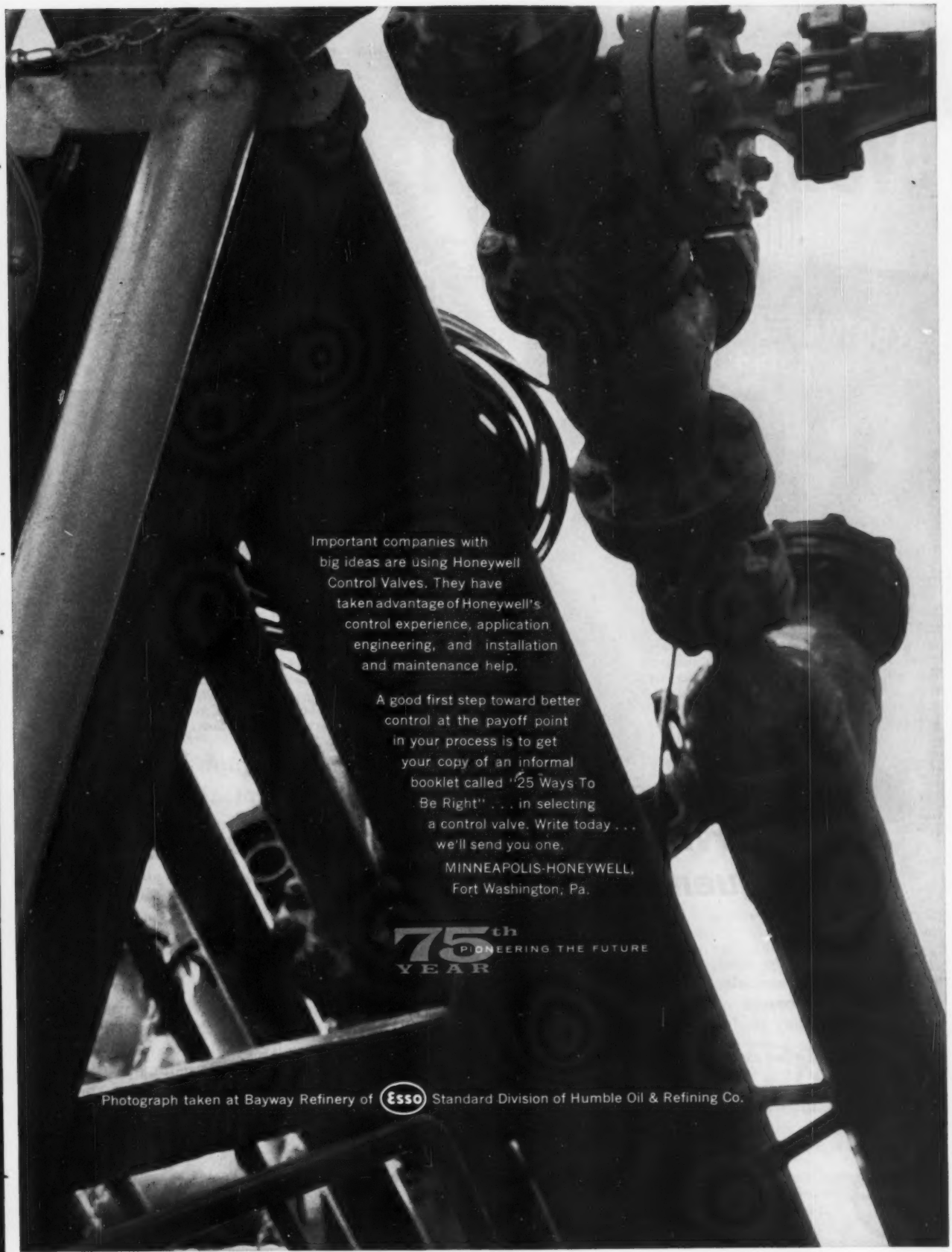
28 pages of facts. Our 28-page bulletin, "Du Pont FOA-2 for Diesel, Heating, Residual Fuels," contains full details on chemical, physical and performance characteristics. Ask your Du Pont Petroleum Chemicals representative for a copy, or write: E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT

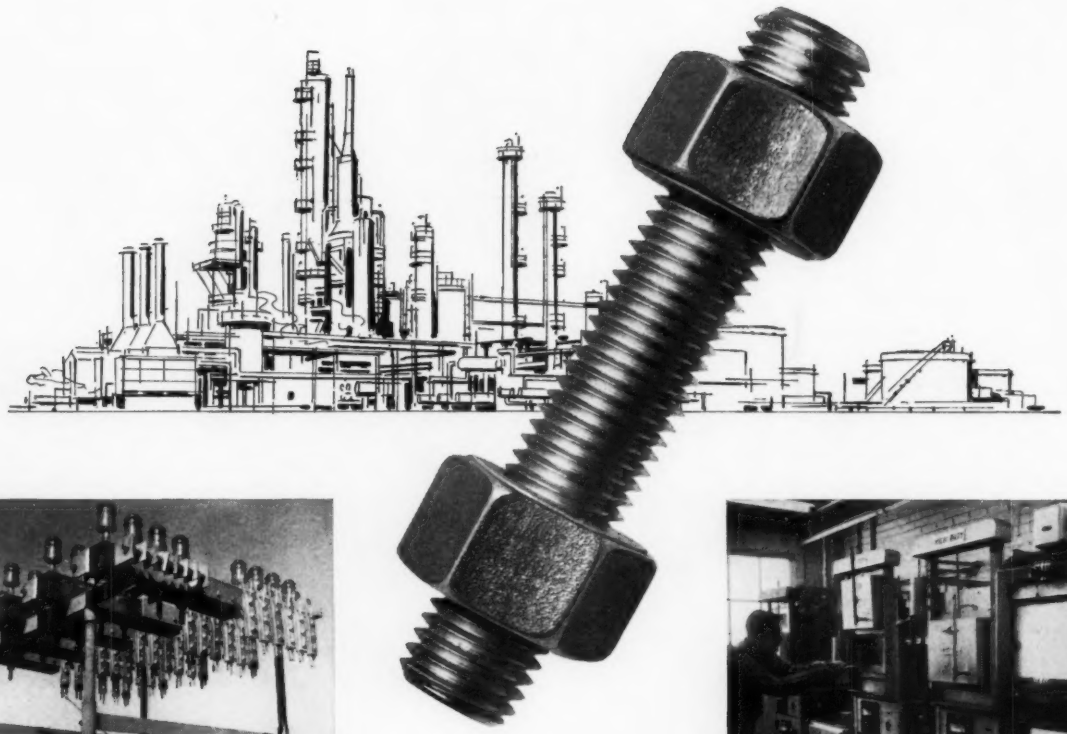
Better Things for Better Living
. . . through Chemistry

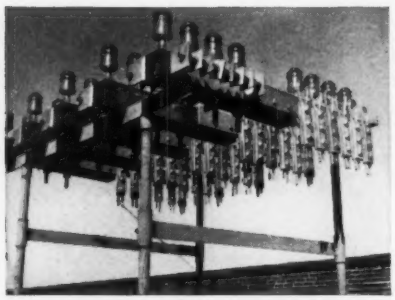
Tetraethyl Lead
and other
Petroleum Additives

Honeywell
First in Control
SINCE 1885

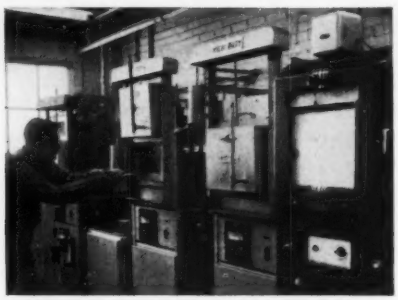

Important companies with big ideas are using Honeywell Control Valves. They have taken advantage of Honeywell's control experience, application engineering, and installation and maintenance help.
A good first step toward better control at the payoff point in your process is to get your copy of an informal booklet called "25 Ways To Be Right" . . . in selecting a control valve. Write today . . . we'll send you one.
MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE
Photograph taken at Bayway Refinery of Esso Standard Division of Humble Oil & Refining Co.

For more data on advertised products, use Readers' Service Cards, last page.





In Refinery Atmospheres—*A two-year test conducted in the severe industrial atmosphere of an oil refinery proved the superior corrosion-resistance of Bethalume over competitive coatings. The competitive items lost their protective coatings at an average of 1.15 mils/yr. The Bethalume-coated products lost at an average rate of 0.05 mils/yr.*



At Elevated Temperatures—*Tests, exposing uncoated and aluminum-coated C1020 steel (1000 hours—1200 deg F), showed a 26.3 pct weight loss in the uncoated steel, but no weight loss in the aluminum-coated sample; proving Bethalume-coated studs and nuts well suited for oil refinery high-temperature connections.*

These test results confirm long service life of Bethalume coating for quenched nuts and alloy studs

The test findings are good, practical reasons why you get more dependable, and longer service life from Bethalume-coated quenched nuts and continuous-thread alloy studs.

Bethalume coating offers these other advantages—

1. Double-layer protection consisting of a pure aluminum coating on top of a metallurgically bonded, iron-aluminum alloy.
2. Uniform coating and clean, sharp bolt threads.
3. Prevention of galling.
4. Oil refinery tests proved that aluminum coating withstands hydrogen sulfide better than any competitive coating, especially at high temperatures.

It all adds up to this: the Bethalume coating offers low-cost bolting for your high-temperature installations. The details may be obtained from your nearest Bethlehem office.

Steel

For strength
. . . economy
. . . versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

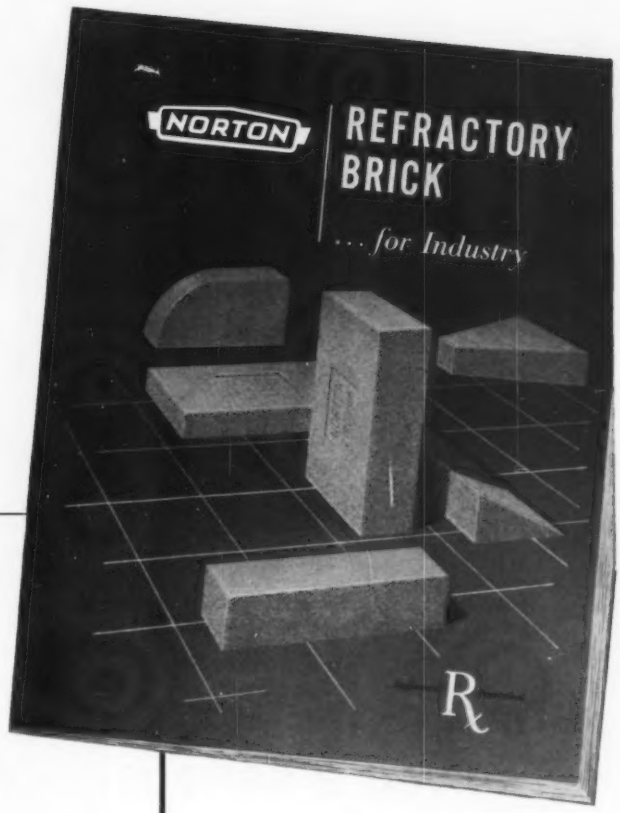
BETHLEHEM STEEL

BETHLEHEM STEEL

For more data on advertised products, use Readers' Service Cards, last page.

Send for this

New Booklet to Help Improve Your High Temperature Processing



Covers Norton refractory brick applications, characteristics, chemical analyses — includes helpful data on materials of construction for temperatures up to 4,400°F.

This new, 24-page Norton booklet can be a dependable guidebook for your selection of the refractories you need to improve production and cut costs in high temperature processing.

Eight Norton-developed refractory materials are covered: ALUNDUM* "T" 87% Alumina; ALUNDUM "A" 99% Alumina; ALUNDUM "L" 99% Insulating Alumina; CRYSTOLON* "G" Silicon Carbide; CRYSTOLON "N" Nitride Bonded Silicon Carbide; MAGNORITE* "K" Fused Magnesia; Zirconia "H" Dense Zirconia; Zirconia "I" Insulating Zirconia.

All essential details are listed, such as: how each material is produced . . . important properties, characteristics and chemical analyses . . . shapes of brick and other molded products that are available . . . representative applications . . . packing methods that assure safe arrival.

Also included are charts and tables of brick shapes and sizes, thermal expansion and conductivity graphs, and a temperature conversion chart.

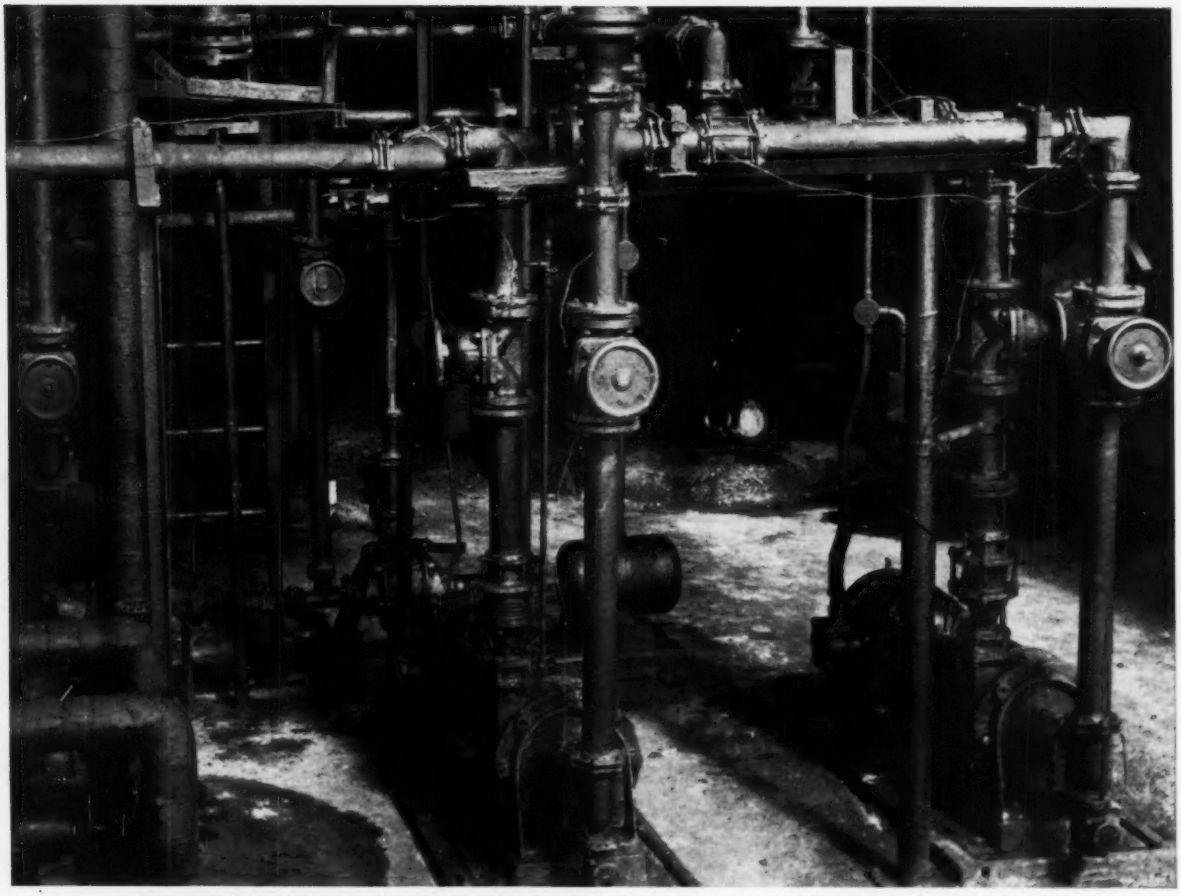
Norton refractories — engineered and prescribed for the widest range of applications — have helped many users save time and money. The ℞'s described in "*Norton Refractory Brick . . . for Industry*" may do the same for you. Write for your copy to NORTON COMPANY, Refractories Division, 467 New Bond Street, Worcester 6, Massachusetts.

NORTON
REFRACTORIES
Engineered . . . ℞ . . . Prescribed
Making better products . . . to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — **BEHR-MANNING DIVISION** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more data on advertised products, use Readers' Service Cards, last page.



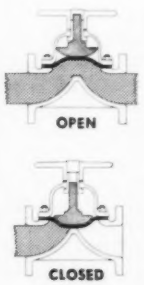
Glass-lined Grinnell-Saunders Valves, with Teflon Diaphragms, on benzene hexachloride lines at Diamond Alkali's Greens Bayou, Texas, plant. Hundreds of other Grinnell Diaphragm Valves are used in other areas of the plant.

How a manufacturer of benzene hexachloride solved a serious valve leakage problem

Valving at Diamond Alkali's Greens Bayou, Texas, plant had become expensive. Leakage of a product containing 30% to 40% benzene and free chlorine released fumes and caused rapid corrosion of the metal parts of the valves used previously, as well as of adjacent equipment.

This problem was corrected when Grinnell-Saunders Diaphragm Valves were used. The first replacement of any part of the Grinnell Valves did not occur for two years, and this was the diaphragm *only*. The former valves had to be *completely* replaced every one to two months! Bodies of the Grinnell valves lasted four years. In short, when Grinnell-Saunders Diaphragm Valves were installed, stem leaks ceased; corrosion was eliminated; and downtime to install new valves was practically ended.

For further facts about Grinnell-Saunders Valves, see Grinnell's insert in Chemical Engineering Catalog, or Sweet's Plant Engineering File — or write directly to Grinnell Company, Providence 1, Rhode Island.



- Diaphragm lifts high for streamline flow in either direction
- Diaphragm presses tightly to effect positive closure
- No packing glands to need attention
- Diaphragm easily replaced without removing valve body from the line
- Wide choice of body, lining and diaphragm materials

GRINNELL-SAUNDERS DIAPHRAGM VALVES

GRINNELL COMPANY, PROVIDENCE 1, R. I. • BRANCH WAREHOUSES AND DISTRIBUTORS FROM COAST TO COAST
PIPE FITTINGS • VALVES • PIPE HANGERS • PREFABRICATED PIPING • UNIT HEATERS • PIPING SPECIALTIES

For more data on advertised products, use Readers' Service Cards, last page.

Wolverine TRUFIN and STEEL ...go together—naturally!

Where corrosion is not a problem—design and operating engineers are finding that they can cash in on money-saving benefits by specifying Wolverine Trufin in seamless steel.

Trufin – in steel – possesses all of the inherent advantages of integral finned tube. For example:

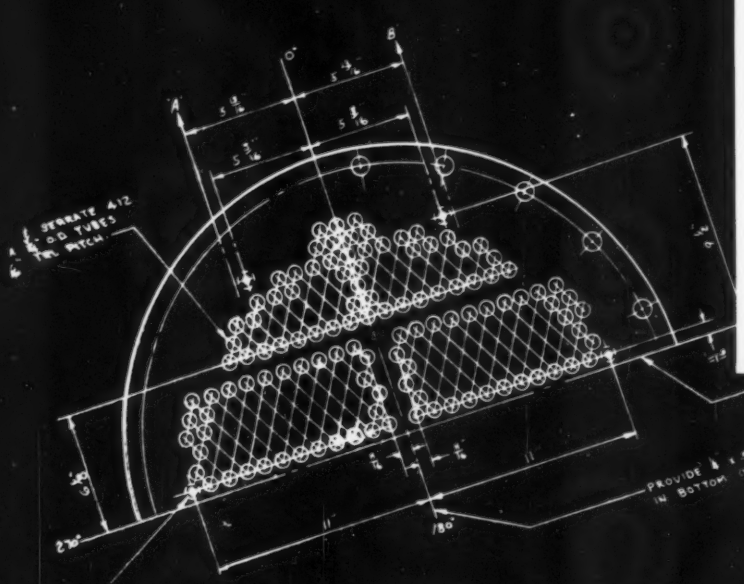
* **In new installations** – Trufin lets you design smaller exchangers without sacrificing capacity. You save on shells, headers, baffles, supports, etc.

* **When retubing**—Trufin's extended surface makes it possible to dramatically increase the capacity of existing exchangers. Trufin Type S/T can be substituted directly for bare tube.

* **Trufin has stamina**—Trufin, because of its integral fins, has the ability to stand up under rigorous operating conditions. Fins are part of the tube wall and are unaffected by the pounding of temperature and pressure changes and vibrations.

Trufin is produced in many types, sizes, and fin spacings – and in steel, copper, copper alloys and aluminum.

WRITE TODAY FOR MORE INFORMATION



Look to Wolverine for the complete line of finned tube

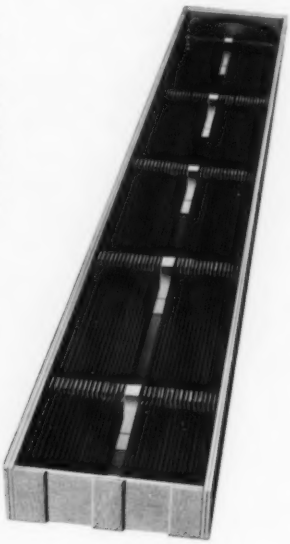
Trufin Type S/T | Trufin Type W/H | Trufin Type S/T (Duplex) | Trufin Type L/C (Bimetal) | Trufin Type H/R | Trufin Type H/A | Trufin Type I/L

Only Wolverine Tube Division of Calumet & Hecla, Inc. can supply you with such a complete line of integrally finned tube – seven different types designed to bring increased efficiency to a wide variety of heat transfer applications. Each type is available in a complete range of sizes and alloys. Ask your Wolverine salesman for information about how these outstanding tubes can help you.

WOLVERINE ALSO OFFERS SPECIAL SERVICES AND SPECIAL PRODUCTS

Wolverine's Field Engineering Service is staffed with specialists trained in tubing selection, alloys, metallurgy, equipment design, etc. Also available for consultation are Wolverine's Heat Transfer Specialists who are located throughout the major processing areas. The services of all these men are yours –without obligation.

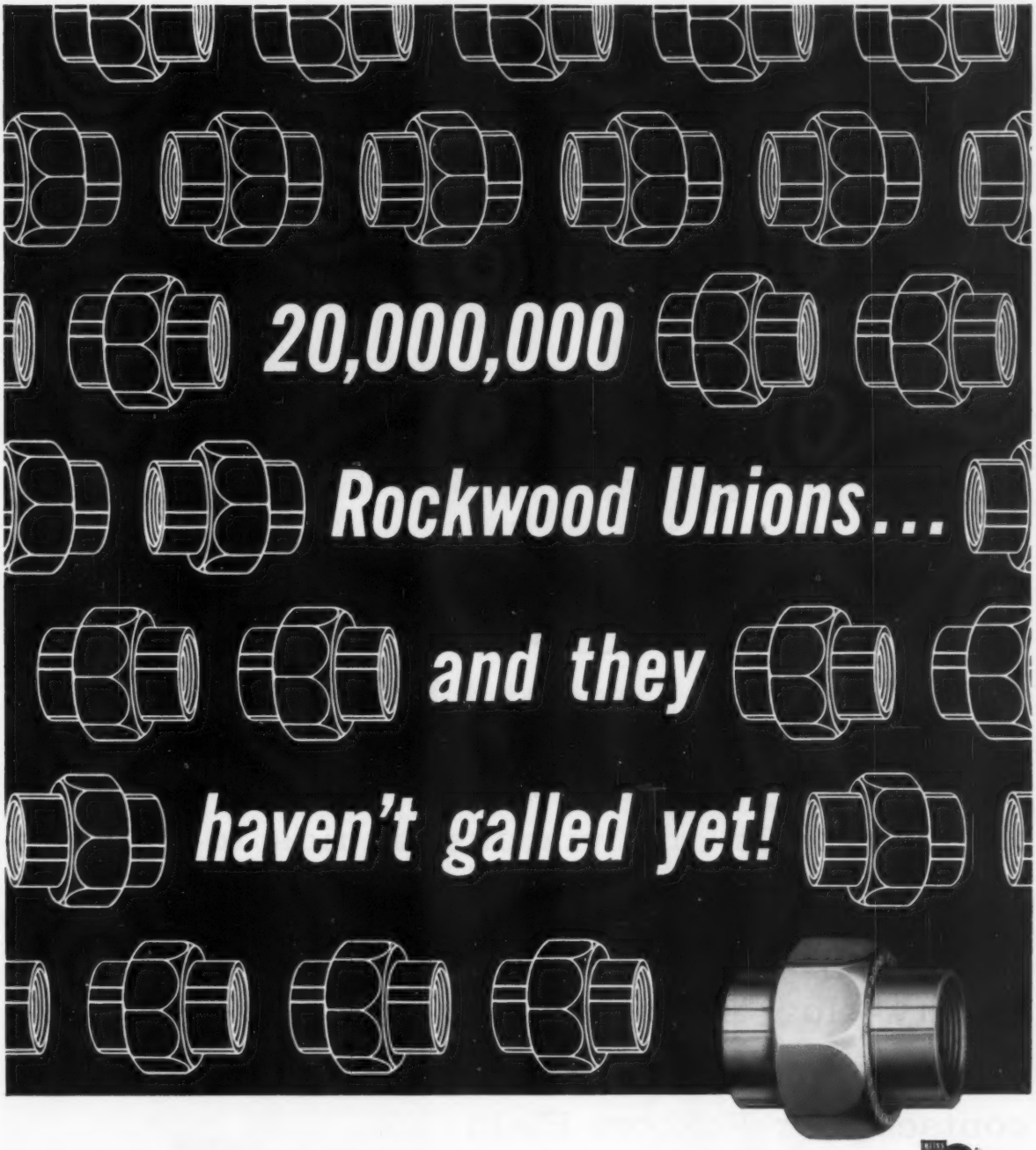
. . . AND, OF COURSE, WOLVERINE TUBE also manufactures a complete line of copper, copper alloy and aluminum prime surface condenser tube. Ask your Wolverine sales representative about Wolverine's complete line of products and services.



Wolverine Tube is also a prime mill source for palletized U-bend condenser tubes–manufactures them to your "specs" and ships them to you in disposable box-type pallets so that you can feed directly from pallet to condenser.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. D, 17236 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality-Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES



Only ROCKWOOD Cold Forged Steel Unions have the hardness differential which *assures* fast, easy make-up, a tight seal, and free from galling. Male seat is heat-treated to a hardness substantially higher than that of the female seat. Then both seats are forged in place and double-locked under 100,000 and 400,000-pound pressures. Other outstanding features include: special color-coding for immediate identification. Rockwoodizing which gives all surfaces *positive* protection against corrosion, interchangeable parts. Get complete information now. Write for facts.

ROCKWOOD SPRINKLER DIVISION

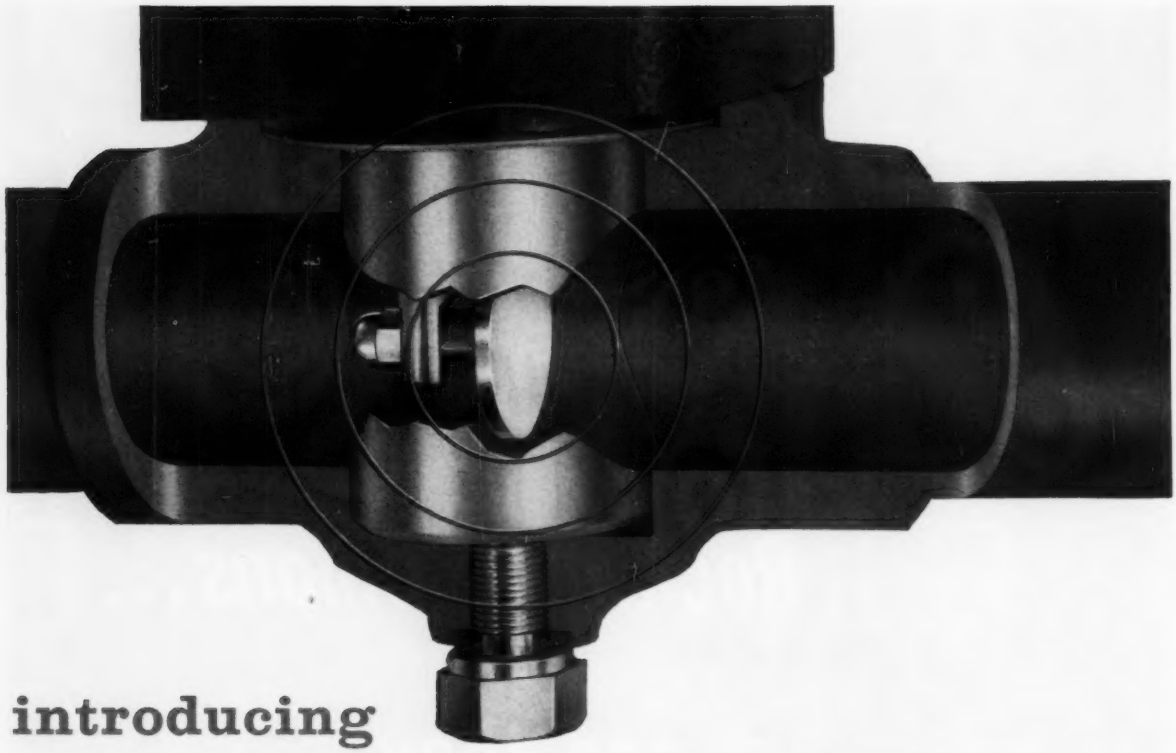
Distributors in all principal industrial areas

ROCKWOOD SPRINKLER DIV.
of The Gamewell Company
A Subsidiary of E. W. Bliss Company
722 Harlow Street
Worcester 5, Massachusetts

Please send me prices and further information on Rockwood Unions.

Name .....
Title .....
Company .....
City ..... *Zone* .....
State .....

For more data on advertised products, use Readers' Service Cards, last page.



introducing the Foxboro Target Flow Meter

new, improved way to measure the "tough ones" ... heavy oils and viscous liquids to 750° F— installs directly in line ... no pressure taps to foul or plug up—high repeatability—low maintenance—write for TI 37-84a, or contact your Foxboro Field Engineer.

The Foxboro Target Meter is installed directly in the flow line. A stainless steel "target," extending into flow stream, senses mechanical force of fluid pushing against it. Force is then converted to a pneumatic signal and transmitted to a remote recorder or controller.

FOXBORO
REG. U. S. PAT. OFF.

THE FOXBORO COMPANY
748 Neponset Ave., Foxboro, Mass.

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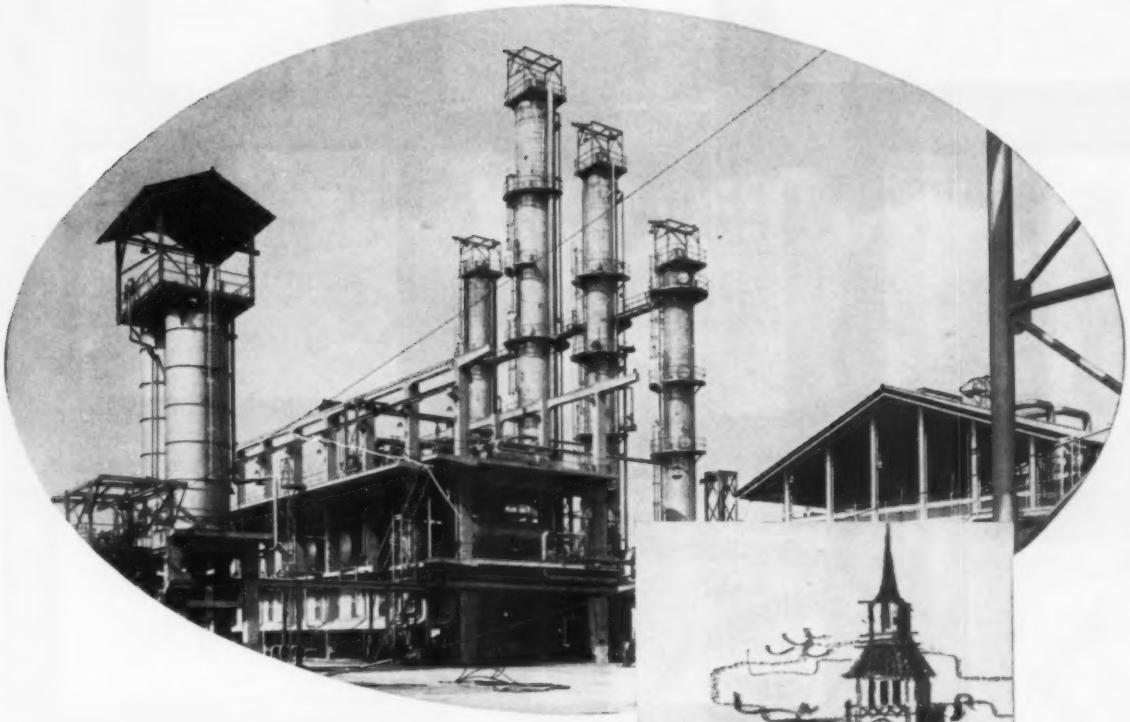

PENNY WISE . . . DOLLAR WISER!

Your process construction dollars buy more . . . when you entrust the job to Procon. Construction-wise Procon purchasing men, engineers and other personnel, go all out to get you the most for your money:

They balance cost against performance . . . hold purchases strictly in line with your budget . . . check and recheck components large and small for materials, tolerances, stresses . . . provide a running account of purchases, a constantly current balance sheet, down to the last penny.

Procon builds plants that perform as intended . . . with materials, parts and components bought the way you'd buy them yourself, if you had the necessary time, facilities and personnel.

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS, U.S.A.

PROCON INTERNATIONAL S. A., CHICAGO, ILL., U. S. A.
PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA
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PROCON®

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, CHEMICAL AND PETROCHEMICAL INDUSTRIES

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HOW DO YOU MEASURE ENGINEERING EXPERIENCE?

Graduate degrees, professional licenses and society memberships are important to an engineering company. The actual accomplishments of the men who earned such honors are even more important.

Chemico engineers have a reputation for designing and building plants which start up on time and operate smoothly and efficiently. This reputation was earned by performance—performance on chemical and petrochemical projects with a total erected value of more than $1,000,000,000.

If you are planning to build or expand process facilities, Chemico's engineering experience can be put to work for you. Learn more about Chemico by writing to the address below, *attn: Sales Department.*

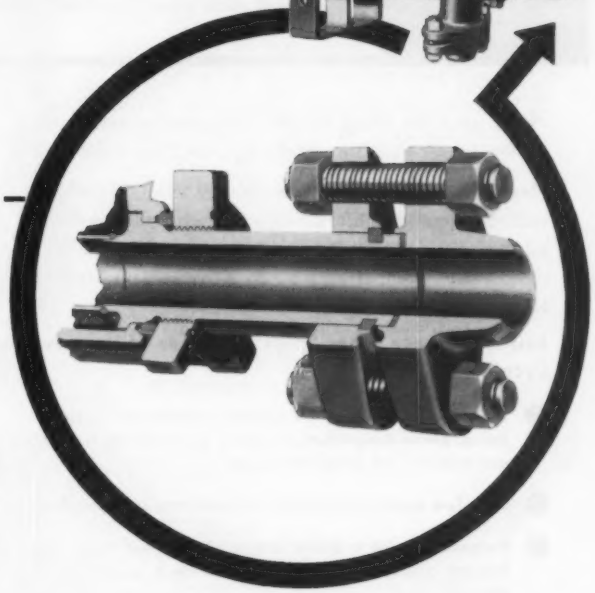
CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

CHICAGO • DALLAS • PORTLAND, ORE. • TORONTO • LONDON • PARIS • JOHANNESBURG • TOKYO

A NEW ADDITION TO A FAMOUS FAMILY

Type O Low Pressure Heat Exchangers



Improved Head Design Reduces Maintenance and Installation Costs to an All Time Low!

- **FORGED HAMMER LUG HEAD TO TUBE CLOSURE:** No troublesome bolting or swing room required. Unit easily accessible from front end.
- **TWO STUD FLANGES:** Greatly simplifies installation and maintenance over multi-stud fixed or lap joint type flanges.
- **EASY REMOVAL OF TUBE ELEMENT:** Pulls straight out without removal of any tubeside piping.
- **ALL CONNECTING FLANGES FURNISHED:** A savings well worth evaluation!
- **FAMED BROWN METAL SEALING RING CLOSURE:** The most accurate closure ever developed.
- **MISALIGNMENT IMPOSSIBLE:** Shell nozzle inlet and outlet are precision machined, integral units.
- **LOW INITIAL COST:** Sweeping design changes result in simplified, low-cost construction.

Send for the Complete Story on these Cost Reducing Units

Bulletin 110 shows how to reduce heat exchanger costs. Write Brown Fintube Company, Dept. PB, 300 Huron Street, Elyria, Ohio. 'Phone FAirfax 3-3291.

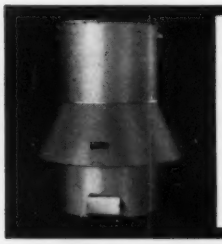
HEAT EXCHANGE SURFACE
BROWN FINTUBE
HEAT TRANSFER PRODUCTS

BROWN FINTUBE

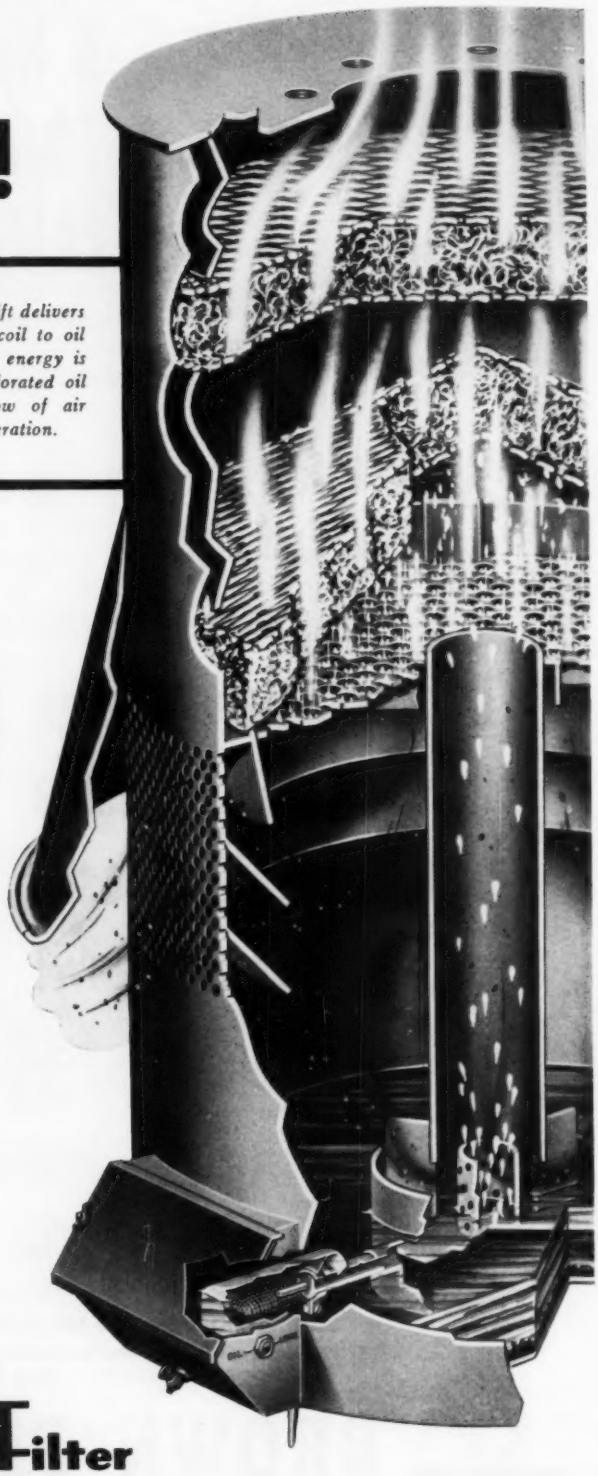
SYMBOL OF EFFICIENCY IN HEAT TRANSFER PRODUCTS

For more data on advertised products, use Readers' Service Cards, last page.

NEW AAF Cycoil air cleaner has no moving parts!



HERE'S HOW IT WORKS—*Pneumatic oil lift delivers oil from reservoir at bottom of Cycoil to oil distribution plate. Source of lifting energy is the static pressure drop across perforated oil distribution plate, resulting in flow of air through plate when Cycoil is in operation.*



Now, an even more trouble-free engine and compressor air cleaner from AAF: the new Type P Cycoil!

Here's the *only* oil-bath air cleaner available which utilizes pneumatic lift, doing away with any need for oil pump and motor. And with pump and motor "designed out" there is nothing to lubricate, no brushes to replace, no circulator to wear out.

Just read these other "plus" features of the new Cycoil:

- **No wiring or on-site power needed; no problems of voltage rating, phase designation, or special protection for hazardous locations. No power bill to pay!**
- **Same low operating resistance and wide range of operation.**
- **Pneumatic oil lift a structural part of the inner Cycoil. No external piping or connections, with their possibility of oil leaks.**
- **Improved method of sludge removal.**
- **Shipped completely assembled. Just provide suitable supports and attach to air intake pipe!**
- ***Absolutely no sacrifice* in the quality of performance and construction which have characterized AAF's Cycoil line for 25 years.**

Interested? Get complete information from your nearest AAF representative, or write direct for Bulletin 160. Address: Mr. Robert Moore, American Air Filter Co., Inc., 452 Central Ave., Louisville, Ky.

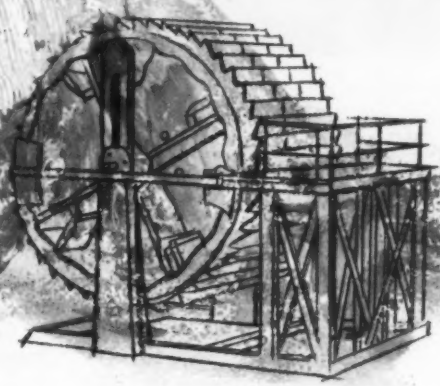
AAF **American Air Filter**

BETTER AIR IS OUR BUSINESS

THE QUALITY OF THINKING

From an almost unlimited scope of thought, Leonardo da Vinci brought forth a stream of inventions which — in modern form — are in use today. However, Leonardo's greatest contribution was simply the triumph of creative thought applied to practical results. His work will stand for all time as proof that the appraisal of quality applies to thinking as well as to tangible objects and to visible or audible processes.

In a related sense, the quality of engineering is measured by results. And it is by results alone that the minds responsible for an engineering project can be evaluated. When you check the record of Brown & Root's engineering through the years, the high quality of thinking is self-evident. Customer satisfaction from greater efficiency at lower costs has built a worldwide reputation for engineering and construction by Brown & Root.



This squirrel-cage blower, invented by Leonardo da Vinci and put to practical use, was a significant step toward modern mechanical air conditioning.

BROWN & ROOT, INC.

Engineers · Constructors

POST OFFICE BOX 3, HOUSTON 1, TEXAS

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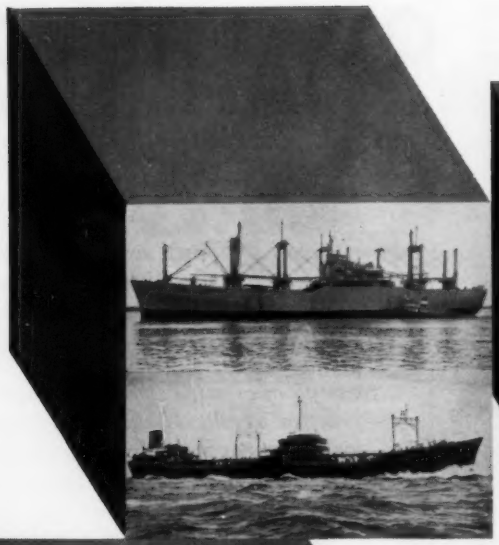

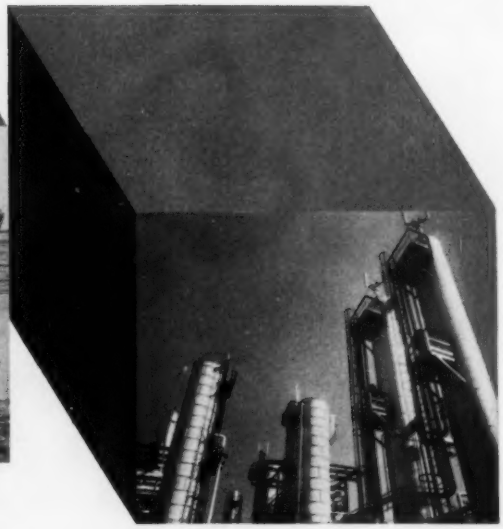

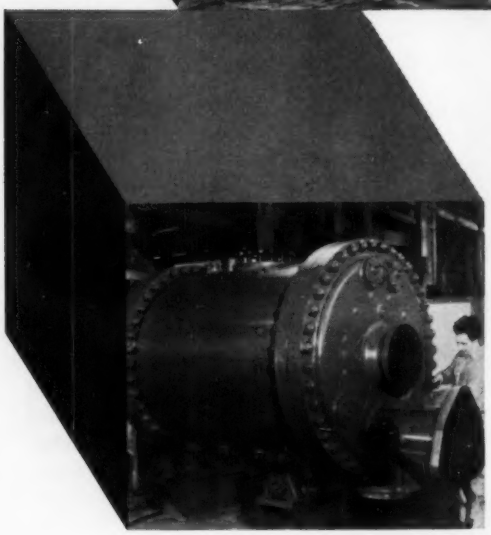

SUN SHIP built 'em all....

Our reputation as "master builders for land and sea" is based on 44 years' service to the oil-refining, chemical and other industries.

Frequently we are called upon to produce components for the building of large plants. Our manufacturing and fabricating skills, our understanding of industry's problems are reflected in the variety of equipment we build, like the fractionating towers and special pressure vessel shown here.

In our complete, modern shops we build and *deliver* what's needed in many fields. Our special Alloy Products Shop, for example, is equipped to produce medium and heavy stainless alloy and aluminum products for industry.

Building for land • Pressure vessels • Fractionating towers • Stills and tanks • Condensers and similar equipment • Special machinery • Plate work, etc.

Building for sea • Dry cargo ships • Tankers • Marine repairs • Dredges • Ferries • Marine engines • Marine machinery.

Sun Ship does a big job for many companies, and can do the same for you.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

For more data on advertised products, use Readers' Service Cards, last page.

New heat-resistant alloy

SUPERTHERM

(Trade-mark)

for castings operating in the 1800-2300°F range

DEVELOPED AT OUR RESEARCH LABORATORIES

in Mahwah, N. J., Supertherm is field tested and proved. It is a superior alloy in this temperature range for static, centrifugal and shell-molded castings.

Mail the coupon, below, for technical information on composition*, physical and high-temperature properties.

*Patent Pending

Electro-Alloys Division
2026 Taylor Street
Elyria, Ohio

Please send me technical information on SUPERTHERM

Name_____

Title_____

Company_____

Address_____

City_____ Zone___ State_____

American Brake Shoe Company

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

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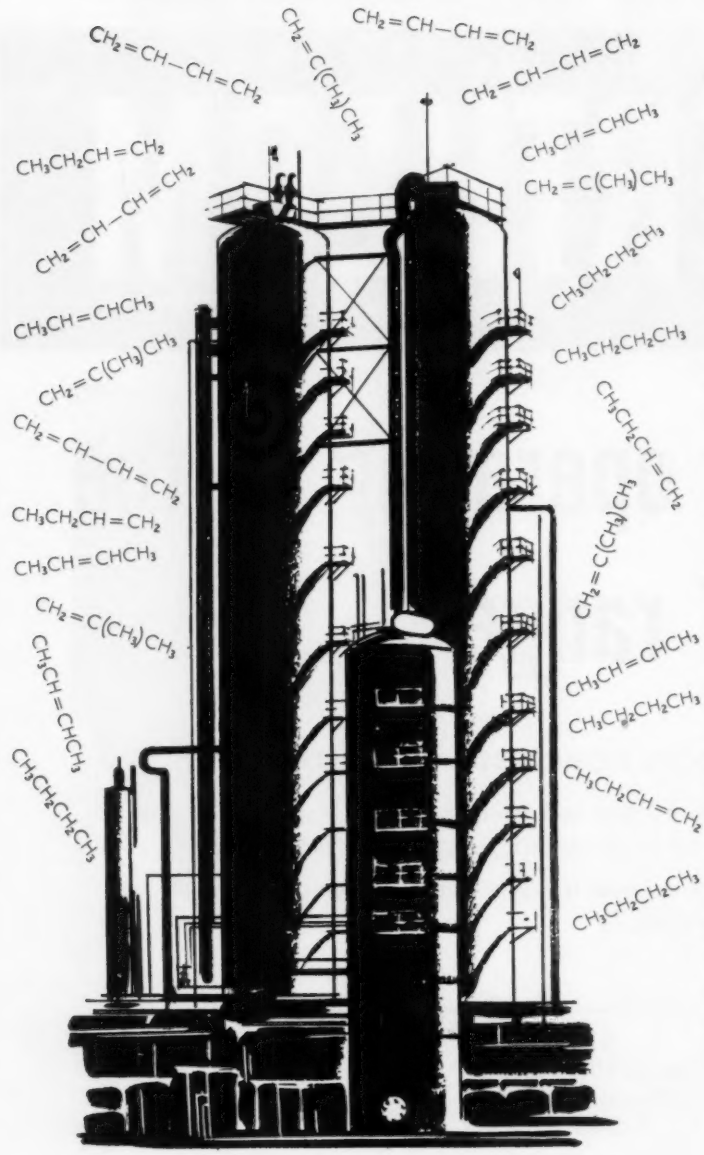
what QO® FURFURAL offers in extraction of butadiene



QO Furfural has the unique ability to alter relative volatilities of butadiene and other C_4 hydrocarbons. This permits easy fractionation of compounds differing in degree of unsaturation. In addition, QO furfural offers:

HIGH RECOVERY: Good selectivity of the solvent assures high butadiene recovery; excellent stability of the furfural assures almost quantitative recovery of the solvent itself.

FLEXIBILITY: Furfural is effective in separating mixed butylenes as well as butadiene, thus a furfural unit can be used to prepare either alkylate stock or butadiene. The process employs petroleum-type equipment, which can be adjusted to a variety of operating conditions.

LOW SOLVENT COST: QO Furfural is produced in large quantities from agricultural residues—not from the valuable food or fiber portions of the plant. This helps keep prices low and stable.

Think of furfural whenever you want to separate a mixture of hydrocarbons. C_4 separation is but one example. Write for information on extractive distillation and Bulletin 203-A containing Physical Data.

The Quaker Oats Company
CHEMICALS DIVISION

The Quaker Oats Company — CHEMICALS — QO FURFURAL CHEMICALS — DIVISION

340P The Merchandise Mart,
Chicago 54, Illinois

Room 540P, 120 Wall St.,
New York 5, N. Y.

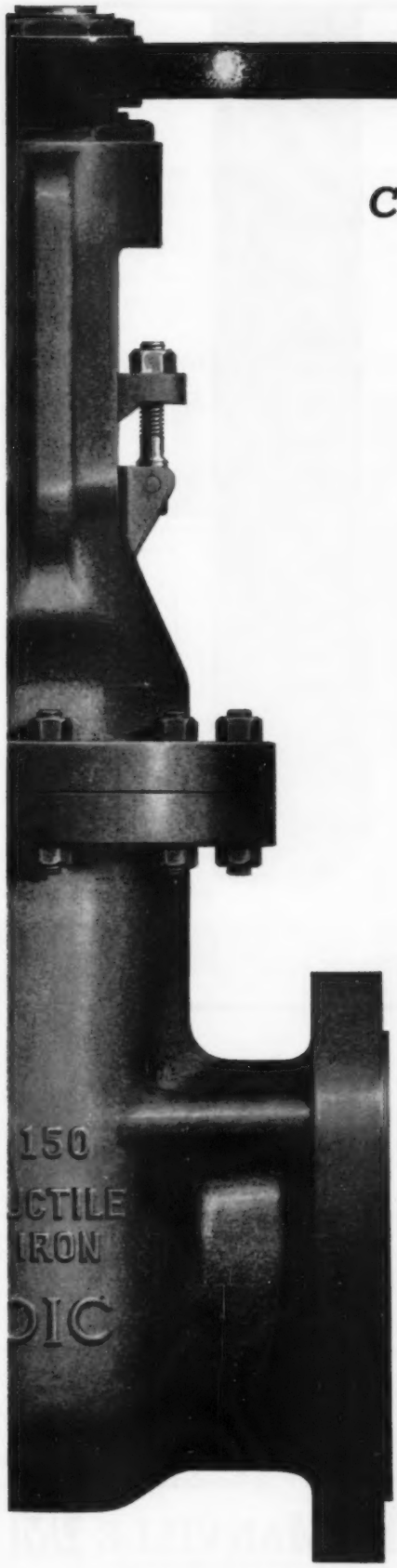
Room 440P, 48 S.E. Hawthorne Blvd.
Portland 14, Oregon

In the United Kingdom:
Imperial Chemical Industries, Ltd., London, England

In Europe:
Quaker Oats-Graanproducten N. V., Rotterdam, The Netherlands;
Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France;
A/S "Ota", Copenhagen, S. Denmark

In Australia:
Swift & Company, Ltd., Sydney

In Japan:
F. Kanematsu & Company, Ltd., Tokyo



CHECK OIC FIRST...IT PAYS!

QUALITY and a reputation for quality are not easily attained in the valve business. At OIC we've worked for more than three-quarters of a century, with one unbroken chain of ownership-management, constantly guarding our standards of quality in materials, design, engineering, craftsmanship, and inspection. This long-standing reputation is reflected in the caliber of your nearby OIC distributor . . . a "quality house" with its own highly valued reputation. When you need valves and must be certain of quality, sight unseen, it will pay to phone your OIC distributor. He carries a representative stock of OIC bronze, iron, ductile iron, cast and forged-steel valves . . . and he can get 4 to 5-day delivery from OIC's warehouses or factory inventory. Since quality is a "must," and delivery is urgent, phone your OIC distributor. Quality products and prompt service are his business, and ours.

OIC VALVES | FORGED AND CAST STEEL, BRONZE, IRON AND DUCTILE IRON VALVES

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

CHEMPAC® (WHITE)

THERMOCORE® (BLACK)

Now—just two J-M styles will handle 9 out of 10 mechanical packing problems!

LET VERSATILE "BLACK" OR "WHITE" HELP YOU REDUCE PACKINGS INVENTORY

Of Johns-Manville's many packing styles, two stand out as "all-purpose" packings. One is for pumps, the other for valves. These two packings not only do an outstanding sealing job . . . they also simplify your packings inventory investment to a minimum.

In 9 out of 10 cases, CHEMPAC and THERMOCORE will handle any pump or valve job in your plant!

CHEMPAC (white) combines the excellent sealing and heat-resistant qualities of asbestos . . . with Teflon's immunity to almost all chemical and solvent action. Chempac Style 2009 will give outstanding service on pumps, expansion joints and agitators.

THERMOCORE (black) consists of asbestos yarns, reinforced with Inconel wire . . . braided over a plastic core of graphite and 100% white asbestos. It remains stable even in valves where line temperatures run as high as 1200 F . . . adapts readily to eccentric motion. Thermocore Style 397 is recommended as the "universal" valve packing.

Johns-Manville produces the industry's most complete range of packing styles. These are described in a new 64-page Mechanical Packings book—the most complete of its kind. In its handy pages, you will find answers to the correct selection of packings best suited to each particular requirement.

For full information on "WHITE" and "BLACK," see your J-M Distributor . . . or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ont.

JOHNS-MANVILLE JM PRODUCTS

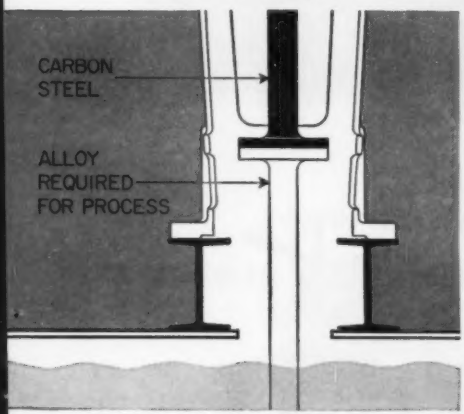
If you want to cut fluid mixing costs
look inside the tank

You can make some of your biggest cost reductions *inside* the tank, when you select a mechanical mixer for fluids.

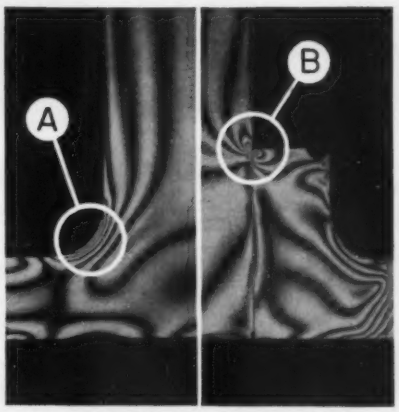
These are *long-term* savings—based on low-cost maintenance, trouble-free service, adaptability to changes in your process, minimum spare-part requirements.

These are the areas where you can *really* save money on fluid mixing. And here are some in-the-tank reasons why you can do it better with LIGHTNIN Mixers than with any other make. For lowest-cost fluid mixing, see your LIGHTNIN representative soon. He's listed in Refinery Catalog. Or write us direct.

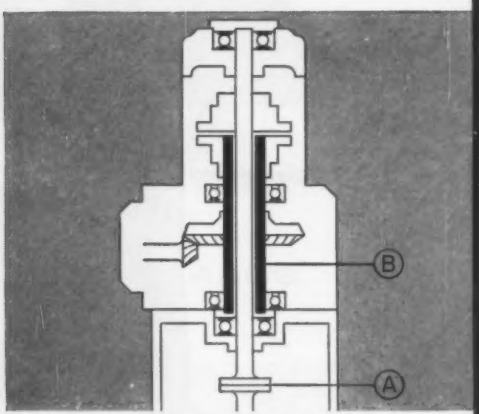
Save 6 ways with these *Lightnin* shaft and impeller refinements



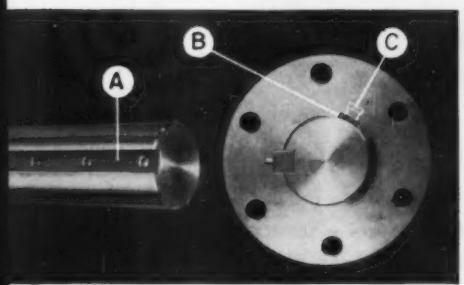
1. Get lower-cost installation, upkeep with two-piece shaft. Standard on open-tank units (available with closed-tank units, too), lower section is alloy required for process; upper section can be inexpensive carbon steel. Rigid coupling has rabbeted joint assuring accurate alignment.



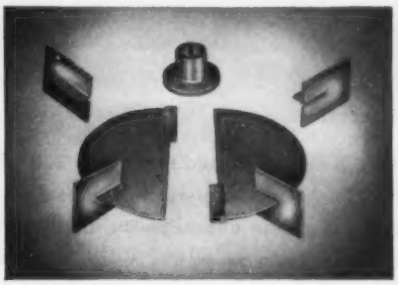
2. You get twice the strength of conventional shaft couplings with LIGHTNIN deep-welded coupling (A). Not one of these couplings has ever failed in service. Polarized light shows how machined and polished radius eliminates stress concentration found in conventional coupling (B).



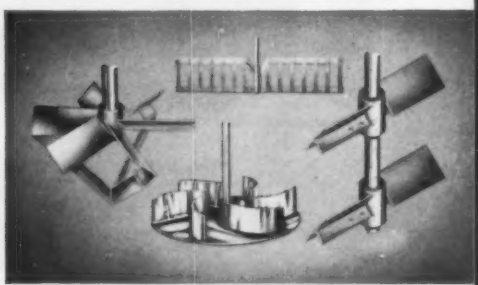
3. No need to disturb gearing if you ever want to replace a LIGHTNIN shaft. Lower shaft is unbolted at (A). Upper shaft slides out of hollow reducer quill* (B). Gears remain untouched—cannot get out of line. When new shaft is installed, shaft alignment is automatic. *Patented



4. Save time positioning impellers. Standard 18-inch shaft keyway (A) provides seven positions (more if you want)—saves you cost of special machining. Also note shallow extra keyway (B) for impeller hub setscrew (C). It permits impeller to slide freely, even if shaft is burred.



5. Cut impeller replacement cost with LIGHTNIN all-bolted design. Replace blades without buying a whole new impeller. Blades come off to pass small openings; or impeller can be supplied split, as shown. Same disc takes 4, 5, 6, or 8 blades for easy change in power input.



6. Get the right impeller for your needs. You can handle practically any fluid mixing requirement with a standard LIGHTNIN impeller. But for special jobs, you can get LIGHTNIN impellers made to specification in all machinable materials and with widest choice of coverings.

WHAT MIXING OPERATIONS ARE IMPORTANT TO YOU? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)

Check, clip and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-h Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

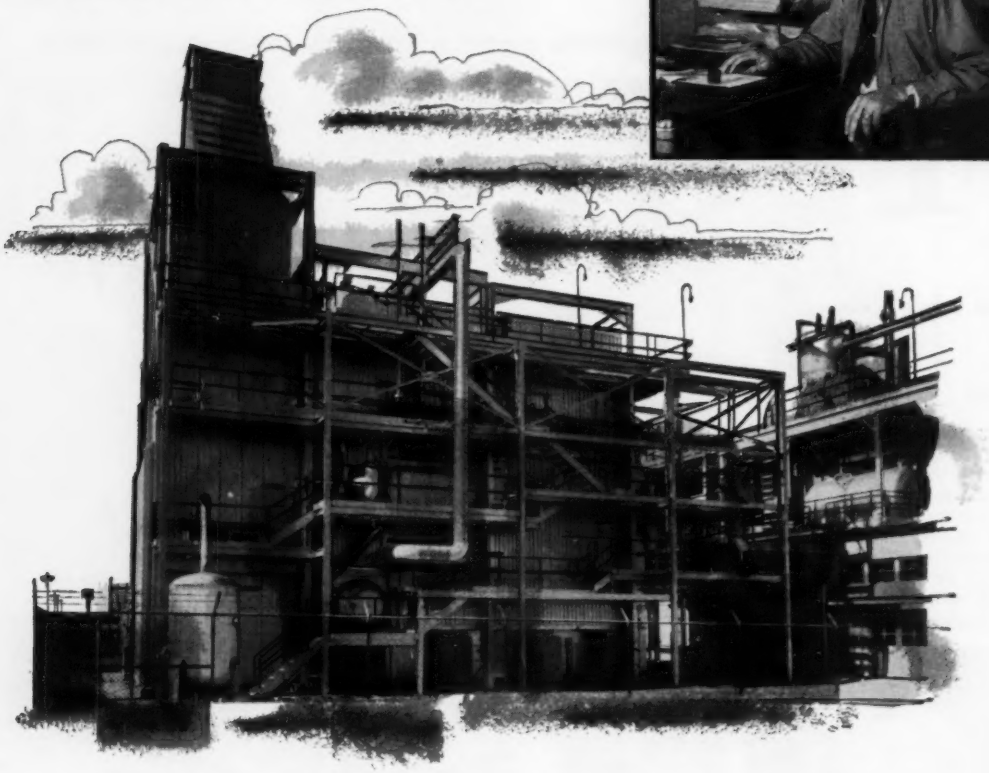
Lightnin® Mixers™

MIXCO fluid mixing specialists

NEW WICKES STEAM GENERATOR

insures maximum efficiency and dependability for BRYAN, TEXAS, MUNICIPAL POWER PLANT

Calvin W. Beard, Superintendent of the Electric Utilities of Bryan, Texas, Municipal System: "As in every other power plant, our steam generator must give completely dependable performance day in and day out".



This Wickes Type RB 2 drum boiler is designed to produce 220,000 lbs. of steam per hour at 875 psig and 900° total steam temperature for the city of Bryan, Texas. The unit performs not only with remarkable dependability, but with Wickes' usual efficiency and economy. Wickes Boiler Co. builds steam generators in sizes to 500,000 lbs. of steam per hour, for high or low steam pressures and temperatures and for all types of fuels and firing methods. See your nearest Wickes representative for full information on a Wickes steam generator designed to suit your needs.

WICKES

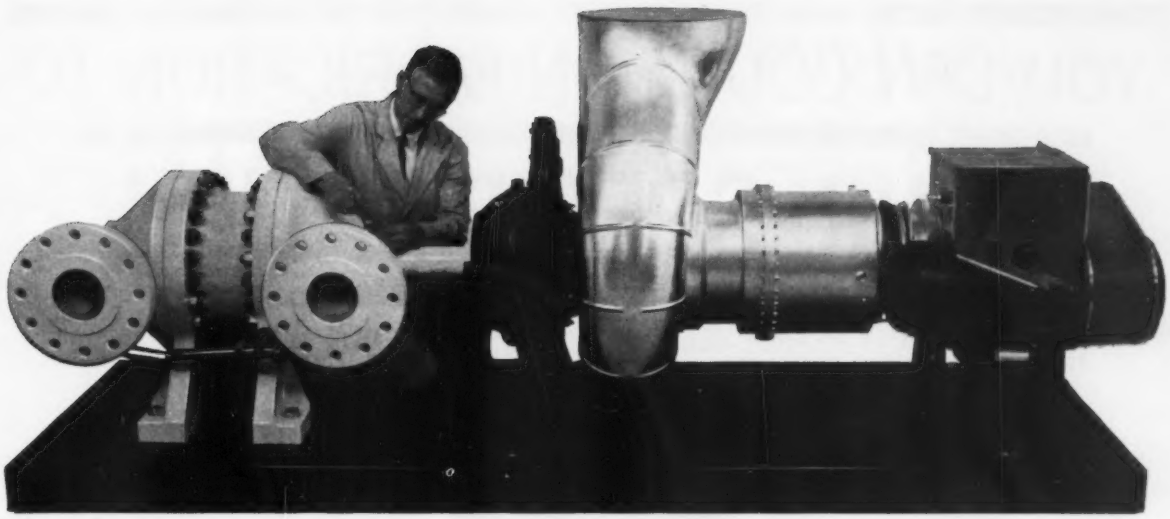
RECOGNIZED QUALITY SINCE 1854

Sales Offices: Atlanta • Boston • Charlotte, N.C. • Chicago • Cleveland Dallas • Denver • Detroit • Houston • Indianapolis • Los Angeles • Memphis • Milwaukee • New Orleans • New York City • Philadelphia • Portland, Ore. • Rochester, N.Y. • Saginaw • San Francisco • Seattle, Wash. Springfield, Ill. • Tulsa

Bulletin 55-1 gives details of a wide variety of designs and sizes of Wickes field-erected and shop-assembled steam generators. Write for your free copy.

174

WICKES BOILER CO., SAGINAW 18, MICHIGAN, DIVISION OF THE WICKES CORPORATION



New Solar gas turbine compressor offers low cost, reliability, easy maintenance

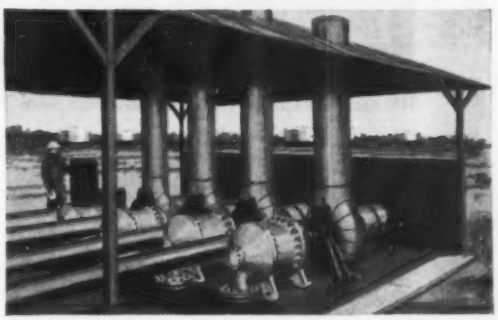
A FUNDAMENTAL ADVANCE in the centrifugal compressor field is available in Solar's new gas-turbine-driven compressor line. These units are particularly adapted for gas compression (both field and main pipeline) and for general industrial use in the low volume range up to 1500 psi.

Long-life gas turbine engines, with rotating speeds of 15,000 to 30,000 rpm, made this breakthrough possible. Driving the compressor directly at turbine speeds has permitted the design of small, high efficiency centrifugal compressors that operate in the range from 75 to 1500 cfm or 5 to 150 MM SCFD.

Features of these compressor packages include: Interchangeable compressor rotors and other parts that allow fast, low cost field changes to meet new flow and pressure requirements. Designed to start and stop in seconds, even by remote control, they are ideal for unattended operation. Small and lightweight, they are easily moved and installed on inexpensive foundations. Maintenance is unusually simple.

Detailed information on Solar centrifugal gas turbine compressors is available. Write to Dept. H-143, Solar Aircraft Company, San Diego 12, California.

Easy transportation for installation or maintenance



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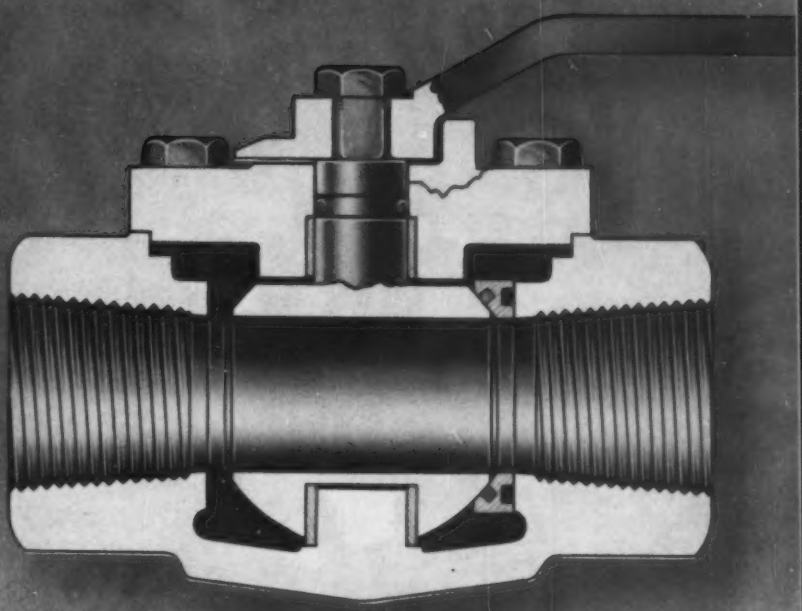

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but, unlike gates, the *FLO•BALL* valve doesn't freeze or jam . . . it never leaks . . . the seats don't score . . . it requires no maintenance . . . and just a ¼ turn opens or closes it.

Better **SEALING** *than a* **GLOBE...**

but, unlike globes, *FLO•BALL* gives zero leakage . . . in both directions *without* seat distortion . . . closes easily without massive operators . . . gives more than twice the flow . . . and the fastest action of any valve made.

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but, unlike plugs, *FLO•BALL never* needs lubrication . . . never freezes, never leaks, requires no maintenance . . . yet it has greater flow capacity than any plug . . . and the *lowest* torque in the industry.

FLO•BALL® does it...and does it better!

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FLO-BALL

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Bearing-fixed ***FLO•BALL*** valves are stocked with flanged or screwed ends, full or reduced port, in standard sizes from ⅛" to 10". They are made to standard ASA dimensions in carbon steel and 316 stainless steel.

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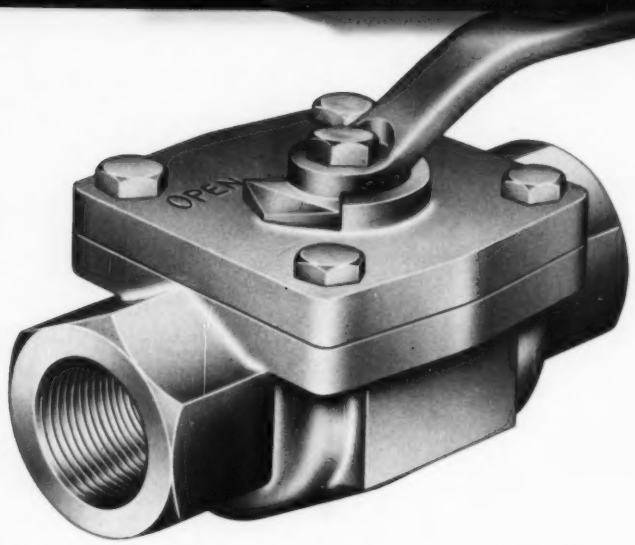

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1. Reduce initial costs . . . *by using fewer valves per system. FLO•BALL valves are used in place of gates, globes, or plugs.*

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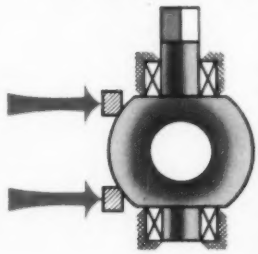
FLO•BALL VALVE
Fixes ball • Floats seat



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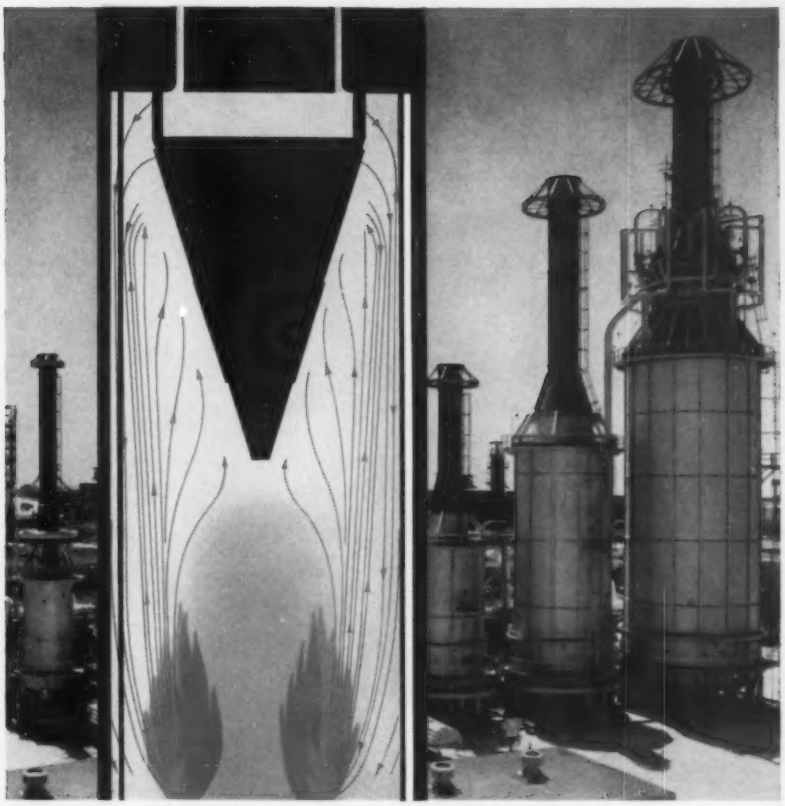

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This is the heart of Petrochem Isoflow Furnaces—the furnaces that get more heat from every measure of fuel. Only Petrochem incorporates all three critical design features so important to highest efficiency in fired heaters: 1) burners specifically designed to furnace needs, 2) properly engineered firebox proportions, and 3) reradiation cones. These factors add up to a more even heat distribution and maximum heat efficiency. Even greater heat efficiency for certain heater applications can be obtained with Petrochem's added convection sections.

Cleaning is easier than with ordinary horizontal-type heaters. Only 25 per cent of the space normally needed is required to pull the tubes of a Petrochem furnace. When specifying furnaces—remember, *there are more Petrochem Isoflow Furnaces in service today than any other make.*

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specialists in process furnaces for every size, capacity and duty

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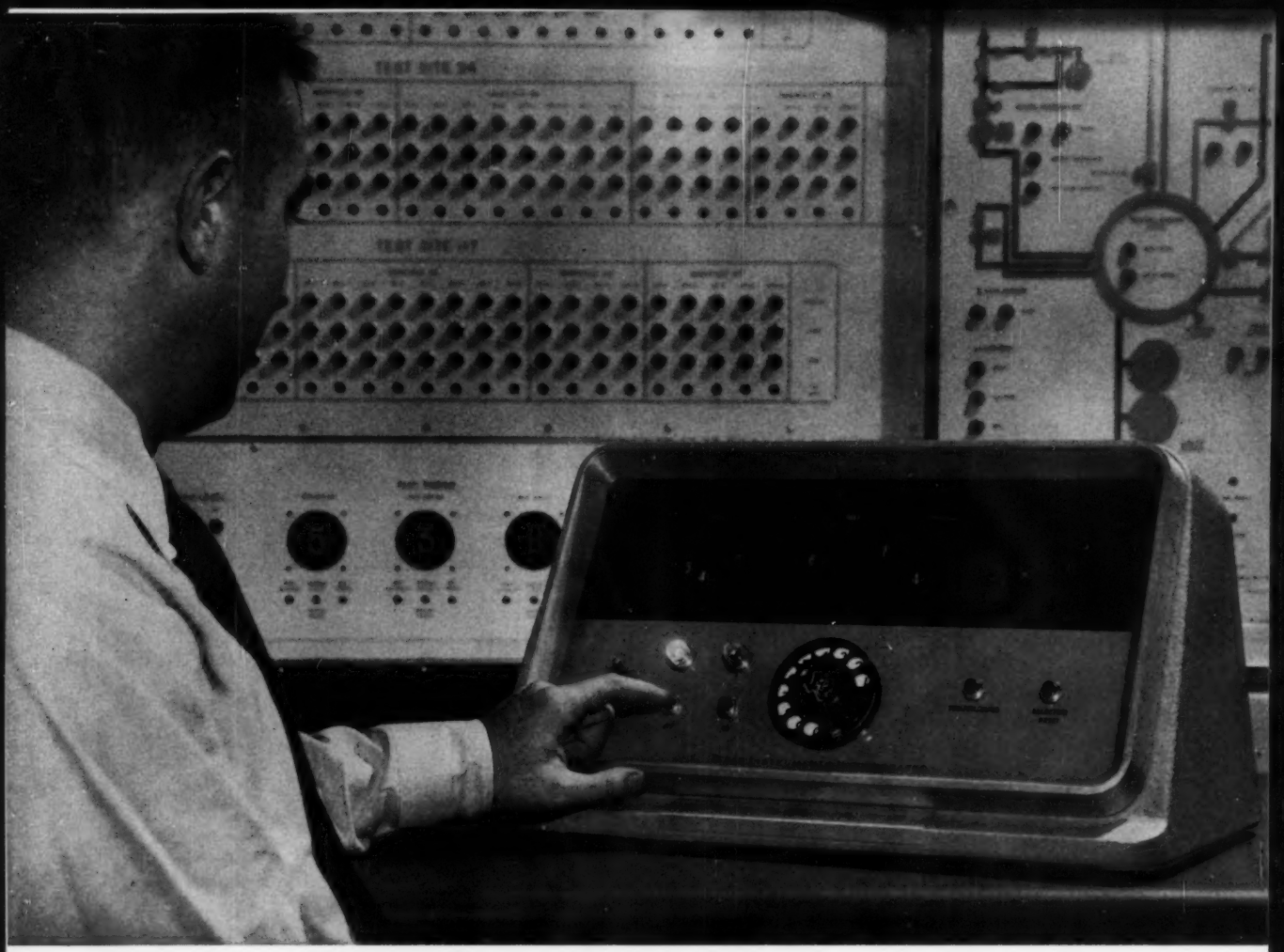

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DATA-GAGE* system is the only field-proved tank gauge system that provides the multi-purpose functions of measurement, alarm and control without extra, expensive control and selector equipment. And, it is the only system that performs all these functions with the high degree of accuracy and reliability you require . . . check these outstanding features carefully:

Accuracy — DATA-GAGE system measures surface level to 1/16-inch accuracy in either stationary or floating roof tanks . . . is accepted for auditing purposes by major oil companies.

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Versatility — *Same equipment* provides: digital and analog measurement including accumulator readout; control for motors, pumps, pilot valves, two- and three-position valves, adjustable chokes, controller set-points, etc.; alarm indication from any sensing contact. DATA-GAGE system can be provided with automatic programmers, data loggers, alarm and status displays.

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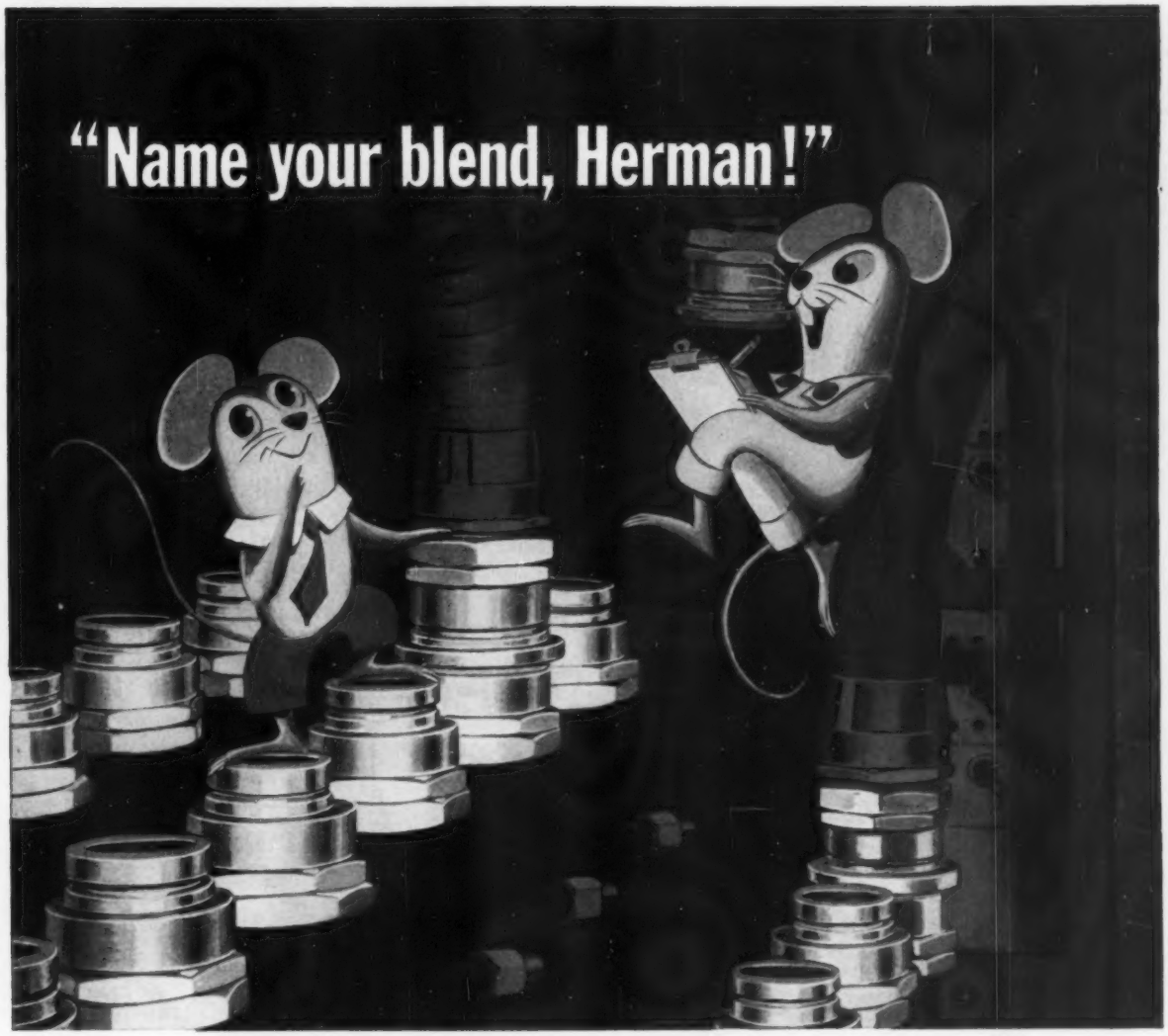

Here's the new, easy way to blend fluids: with Snap-Tite valved couplings on flexible lines

Now, there's no need to laboriously open and close a lot of shut-off valves when you're blending petroleum products or other chemical fluids. With Snap-Tite valved couplings on flexible lines you can quickly switch hoses to any base stock line as required. Mixing is faster: you can perform more operations at one time . . . with no danger of contamination of base stocks by interflow through leaky valves! Valves with Snap-Tite couplings instantly shut off the flow when disconnected, and prevent run-out from overhead lines.

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For information, write for Snap-Tite Catalog No. 59. Ask for the name of your local Snap-Tite representative. There is no obligation.

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CONNECT—Full flow instantly

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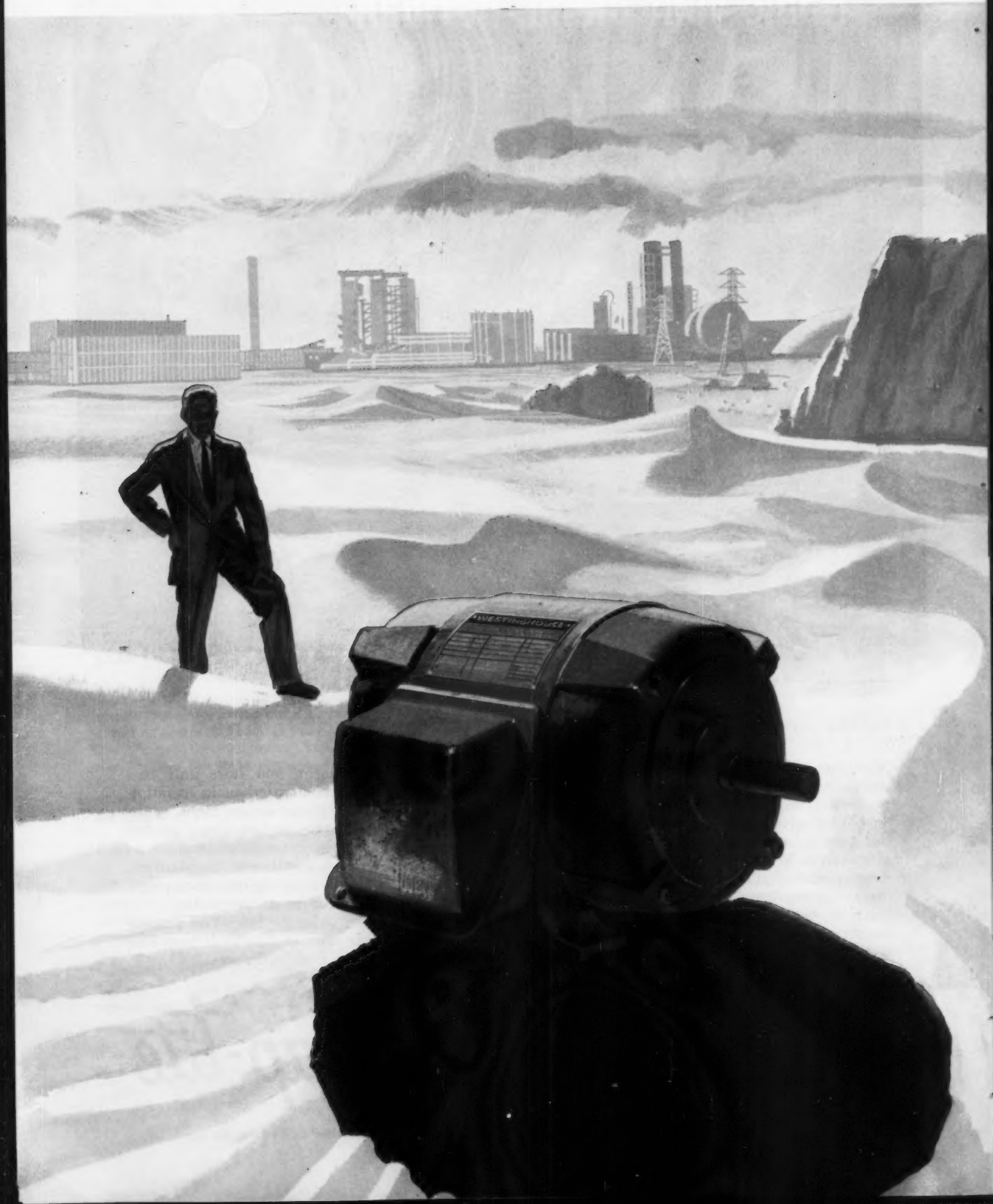
New Guardistor

THE MAN & THE MOTORS



FROM WESTINGHOUSE

Guardistor motors let you match the full capability of the motor to the job— with complete safety—absolute confidence

Our Marketing Manager says:

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
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Our Engineering Manager says:

"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark

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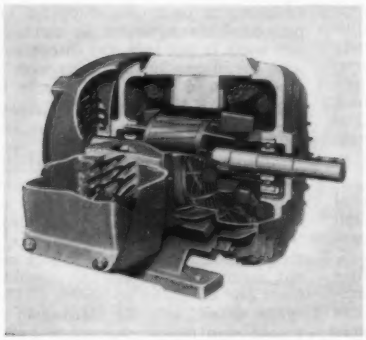
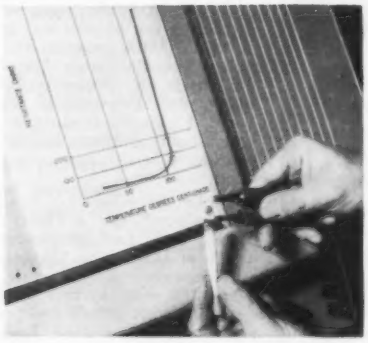


Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

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AUDIGAGE® 6 — the new miniaturized, self-powered "mighty midget" Thickness Gage and Flaw Detector. Ideal for corrosion surveys by one man in awkward locations. Weighs less than 5 pounds complete. Uses new high-sensitivity, high-resolution **Type Z** transducers, flat or curved, in various mounts for every application. Measures directly in inches between 0.09" and 5.0". **BULLETIN A-201.**

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The Mail Box...

Missed the Symbols

To The Editor:

I find the presentation admirable (for "Estimate Ethylene-Methane Separation," May, p 233) . . . but I am perturbed by your last-minute omission of the list of Symbols Used. . . . Although most of the symbols are defined in the text, not all are.

W. A. Mason
Imperial Chemical Industries, Ltd.
Billingham, U. K.

Editor's Note—The symbols are as follow:

A = Absorption Factor = L/KV
e = moles of ethylene
h = moles of hydrogen
K = vapor to liquid equilibrium constant
L = total moles of liquid downflow
m = moles of methane
N = number of theoretical steps from reboiler to overhead product
q = condition of feed factor: approx. ratio of amount of heat to warm one mole of feed from feed temperature and to vaporize it to the molal latent heat
r = ratio m/(m+h)
R = reflux ratio
S = stripping factor = 1/A
V = total moles of vapor up-flow
x = mole fraction of component in liquid
α = relative volatility of light to heavier component

SUBSCRIPTS

$_B$ = bottoms
$_D$ = distillate
$_e$ = ethylene
$_f$ = feed
$_h$ = hydrogen
$_m$ = methane
$_{min}$ = minimum.

"Professional Spirit"

To the Editor:

I am a supervisor in an application engineering department. I possess a B.S. degree in engineering physics and am in the middle of an MBA program at the University of Southern California. For obvious reasons the article on "Professional Spirit" in the May, 1960 PETROLEUM REFINER struck home. I enjoyed reading it and found it sympathetic and supportive. On second reading, however, two questions came to mind.

1) In the subsection headed "Personal Recognition," the article reads: "High morale leads to high productivity." In a course at USC titled "Problems of Personnel Management," we read several other authorities who say that no positive correlation between morale and productivity has ever been substantiated. I would be interested to know if you have discovered positive evidence of such a correlation.

2) Under "Beware of Isolationism," Section 3 (assignments), the article says "No engineer should remain on one job longer than three years in succession." According to the biographical paragraph the author has taught chemical engineering at the University of Texas for 25 years. Does the author feel that his continued effort in that one job has had any detrimental effect on his professional development or has he perhaps compensated for it by accepting consulting jobs? Do you think an engineer working for an industrial firm could equally successfully compensate for an extended assignment on one job through outside contacts such as societies, universities, and customer relations?

Robert L. Chapman
Infra-Red Supervisor
Beckman Instruments, Inc.
Fullerton, Calif.

Here Is Ostrofsky!

We goofed!

Included with Part 3 of a series entitled "Corrosion Measurement Short Course," published in our July issue, we used on Page 148 Gordon Kern's photograph over the name of Ostrofsky, a coauthor of the series.

Ostrofsky

The photograph here is "the real" Bernard Ostrofsky, who is project supervisor in the Research and Development Department of Standard Oil Company (Indiana) at Whiting.

AUTHOR'S COMMENT

The statement "high morale leads to high productivity" was not made without considerable thought. Quantitative evaluation of the two factors involved, though, proved impossible, because I was never able to pin down a satisfactory definition of "morale" and the factors which contribute to it, to such an extent that I could plot "morale" as one ordinate and "productivity" on the other and get a curve relating the two. However, it was based on my general personal observation as a worker and consultant in industry over the past 20 or 25 years and I believe would be fully supportable if one could secure satisfactory definitions of the terms involved.

Incidentally, I made no pretense at all of being a psychologist or an expert in personnel management, so certainly would not want to get into any discussion on this with the instructors or the various "authorities" referred to in any course at USC.

In connection with the statement, "No engineer should remain on one job longer than three years in succession," you called attention to an apparent contradiction in the fact that I have taught chemical engineering here at The University of Texas for 25 years. There is absolutely no contradiction in the two statements, because my statement concerning job changes does not mean or say that one should change from one company to another. The implication was clearly the shifting of activities within any one company or organization which would be of benefit in increased interest on the part of engineers.

As far as my work at the University is concerned, it has certainly been extremely diversified and I have conscientiously, though perhaps not consciously, followed my own advice. I seldom, if ever, teach in the summer time, but use that period for additional study or for industrial consulting. During my time here at the University I have taught, I believe, 14 different courses, 4 or 5 of which I personally initiated. Then, also, I have a new group of students at least once a year and I believe you will agree that this constitutes material change in itself. Really, my only question of my own work is the fact that perhaps

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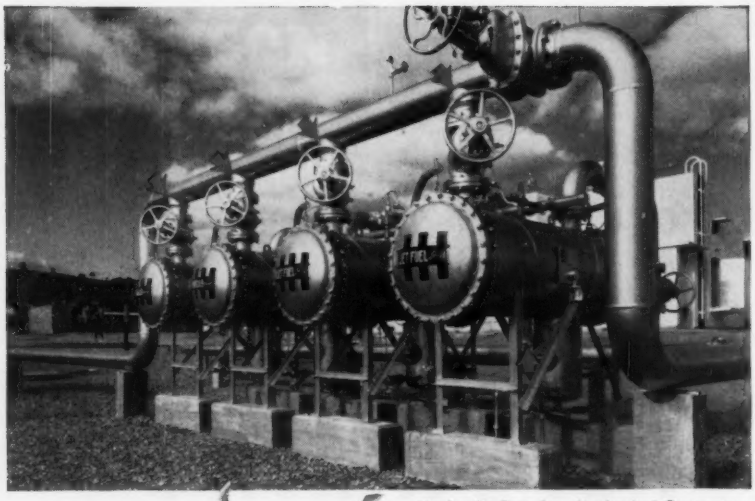

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WELDOLETS were used for all branch connections on pumping station piping

Reinforced branch connections constructed with Weldolet Welding Fittings provide assurance of quality workmanship at the critical branch connection.

Savings in purchase price and construction on this project alone were high in the six figures. Piping designers and contractors who are interested in similar savings on their jobs are invited to write us for the Bonney Spanish Pipeline Brochure.

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the changes have been too frequent.

There is no doubt in my mind, although I cannot cite you quantitative evidence to support it, that any engineer who is working with an industrial firm on a single job assignment, can compensate quite successfully for lack of change by outside activities. Indeed, in this rapidly changing world, unless he does change by the reading of technical literature, by taking special courses, by active participation in technical society meetings and programs and similar activities, not only the engineer but the technical aspects of his job are going to stagnate. Suppose, for example, those of you who are engaged in the development of infrared instruments and applications of same had not participated in the activities indicated above and had been willing to accept the "status quo" of 1950 for future activities, you probably would not now be in business.

Let me point out that the change need not be in the job as such, but that satisfactory results and progress can be obtained by personal efforts of the engineer himself. On the other hand, the changing of jobs is not any assurance at all that the individual will not become isolated from technical developments. So, when you really get down to it, the changes and resistance to isolationism must be within the mind of the individual engineer and the changing of jobs must be looked upon as a means and not the end in itself.

W. A. Cunningham

Shares the Blame

To the Editor:

I have just noticed some errors in my article on "Latest Advances in Superfractionation" (June, 1960). I will share the blame for these since one of them is my responsibility. The corrected equations are as follows:

Page 140, Eq. (3):

$$\Theta = \log \beta / \log \alpha_{top}$$

Page 142, Figure 2:

$$y = x_d = (r)\ (x - x_d)$$

should be

$$y - x_d = (r)\ (x - x_d)$$

Page 143, Eq. (27):

$$(\beta')^{s'} = \left[\frac{x_d'}{x_o'}\right]\left[\frac{1 - x_o'}{1 - x_d'}\right]^{\theta'}$$

Page 143, Eq. (35):

$$(\beta'')^{s''} = \left[\frac{x_o''}{x_w''}\right]\left[\frac{1 - x_w''}{1 - x_o''}\right]^{\theta''}$$

Francis W. Winn
Director of Research and Development
Fritz W. Glitsch & Sons, Inc.
Dallas, Texas

The Editors of PETROLEUM REFINER invite reader comment on topics of timely interest to the oil, gas, and petrochemical processing industry.

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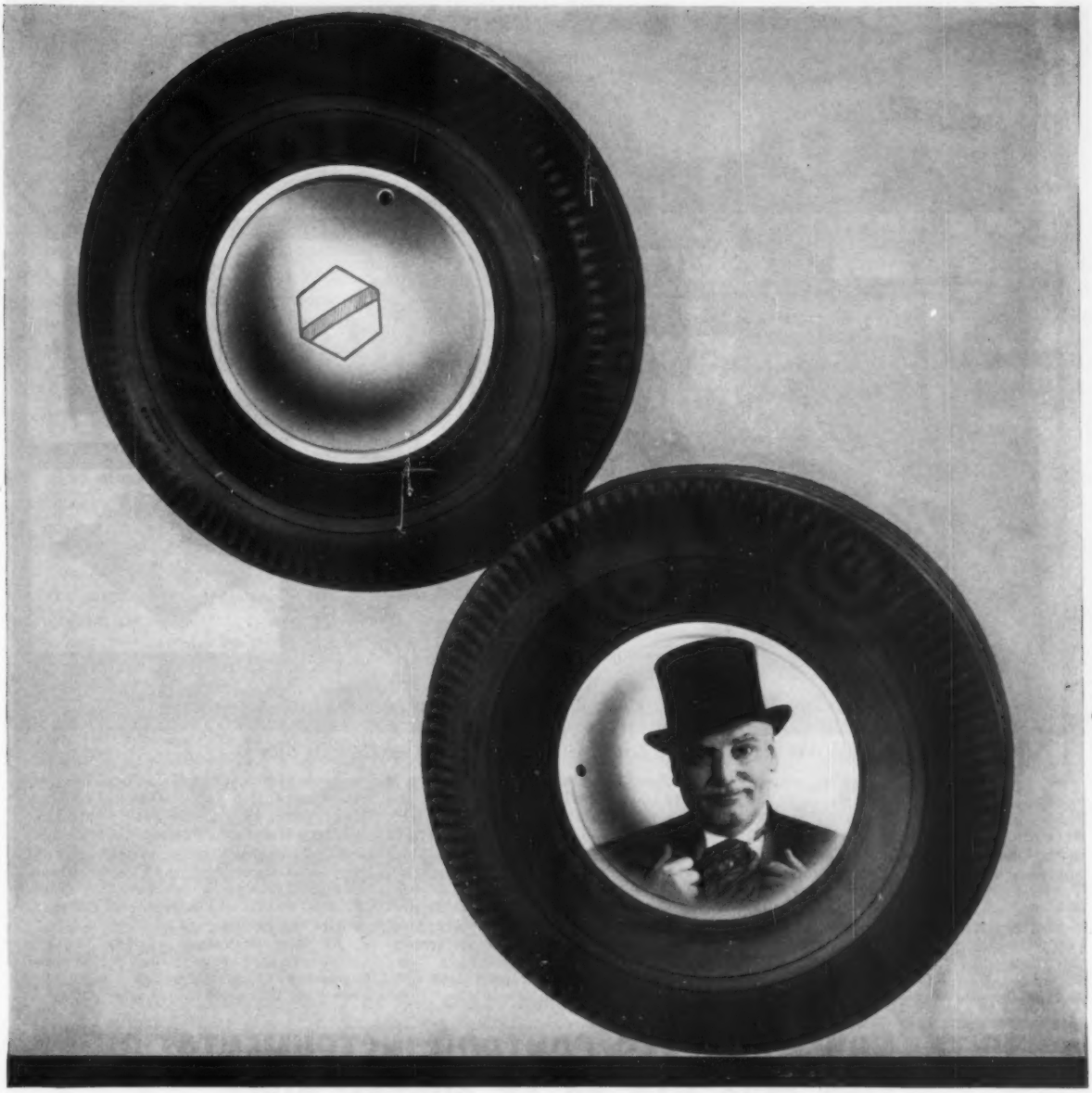

IF TIRES COULD TALK THEY WOULD TELL YOU:

"Very close to 50 percent of the butadiene required for synthetic rubber in the U.S. can be produced by plants using the versatile one-step Houdry Dehydrogenation Process.

"And most of this capacity has gone on stream since 1957, based on a background of serving U.S. industry for over 15 years. It is also producing butadiene in Europe, and two additional units will go on stream in Europe and Asia this year."

By direct dehydrogenation of butane, the Houdry Dehydrogenation Process can produce butene as well as butadiene, and produces other mono- and diolefins from the corresponding saturated hydrocarbons. This flexibility allows processors to switch their output to meet changing market conditions, and the changing demands of the chemical industry. Adapting the process to yield a changed end product is simple and economical.

A description of the Houdry Dehydrogenation Process and the economics of its operation will be sent promptly, on request. When you write, you'll find it well worth your while to ask for an up-to-date outline of Houdry services, too.

***HOUDRY**
PROCESS CORPORATION
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*Houdry means Progress...through Catalysis

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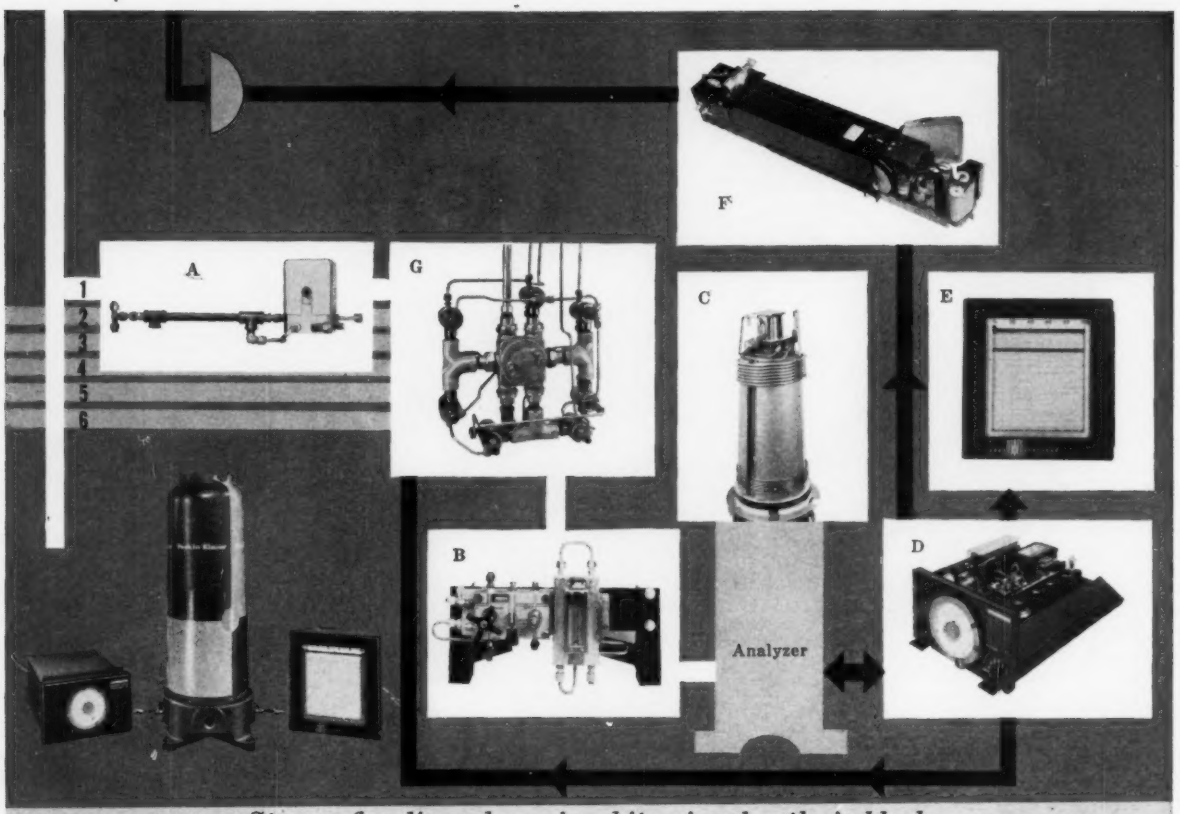

Stream flow lines shown in white, signal paths in black

This block diagram shows how six process streams can be selectively analyzed by the P-E Model 184-B. For brevity, Stream #1 only will be followed through the system.

Stream #1 is tapped, and the sample vaporized in the Liquid Sample Vaporizer (A). Sample #1 then flows (with the other five vaporized samples) into the enclosed, heated Multi-Stream Solenoid Switching Manifold (G). The solenoids are electrically directed by the Programmer (D). As it is selected, Sample #1 is valved into the Final Sampling Assembly (B), where it is filtered and metered into the Analyzer. The Analyzer quantitatively and qualitatively separates the sample's components by gas chromatography, produces signals which appear as a bar graph on Recorder (E).

The signal can also be fed into a Pneumatic Control Accessory (F) which produces a 15 psi signal for automatic control of one variable component of the stream.

The Analyzer with Reverse Flow Valve (C) allows for the analysis of light components individually plus a "total heavies" measurement; it back-flushes and analyzes heavy ends as a single peak, shortening analysis time in the process. The Programmer (D) is available in a variety of modes for multi-component and multi-stream analysis. It controls the Switching Manifold (G) and the Analyzer, and the readout of the Recorder (E).

All flow lines and sampling building blocks are kept above the dew point, where necessary, by steam tracing.

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HOW TO SPECIFY TRAYS

By Frank L. Evans

WHEN SPECIFYING fractionating trays, the engineer must first decide between two basic types of specifications:

- A Duty Specification
- An Equipment Specification

The Duty Specification is used most often when specifying some of the proprietary tray types, such as valve trays, because the tray design procedure is not widely available. It is also often used by the engineer who wants to get a greater capacity or tray efficiency when replacing existing trays. Sometimes there can be a conflict from the start between the owner who doesn't want to reveal process information and the tray fabricator who doesn't want to reveal tray design procedure. The important thing to keep in mind is that when specifying the duty or service in which they will operate, the mechanical designer *must* have enough process information to size and detail the trays. Generally the vapor and liquid rates together with the densities are the minimum information needed. Oftentimes though, more process information will give you a better tray design.

Many process engineers have their own idea about how a tray should be designed. They have seen different types in action and feel that, from their experience, a certain detail should be incorporated into the tray design. For instance, many engineers have very definite, fixed opinions on the hole diameters used in sieve trays. If they specified this hole diameter *in a duty specification* without doing the tray design themselves, they defeat the entire purpose of a duty specification. They should let the fabricator decide on the hole size because mechanical calculations could show that the hole diameter preferred by the process engineer would not work at optimum efficiency for his process conditions.

The Equipment Specification is generally preferred by engineers in the petrochemical industry because they know intimately the complex, non-ideal fluids they are fractionating, they can control the safety factors in tray design because they do the design themselves, and most important they don't have to reveal details of the process to anyone. The equipment specification is also used frequently when replacing existing trays at the end of their expected life. This specification gives the fabricator all of the details needed to make the tray. The articles in this report spell out those details which are required in the specifications to fabricate the desired tray.

This is the type of specification most often used with the well known bubble cap type tray. However, one fabricator states that the bubble cap trays being specified today represent only 20 percent of the tray business. Designers obviously feel in general that the newer tray types offer improved advantages over the bubble cap tray.

Although several of the tray types you have heard about are not covered in this report, the most popular types being used today are included. (Note: There are variations in the valve type design between fabricators—all of which are very popular).

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TRAYS

How to Specify Fractionating Trays

"A knowledge of how to specify fractionating trays helps the process designer set the proper objectives for some of his calculations. It helps define the responsibilities of those participating in the project. And it is especially useful in clearing the way to a satisfactory cooperation between manufacturer and user."

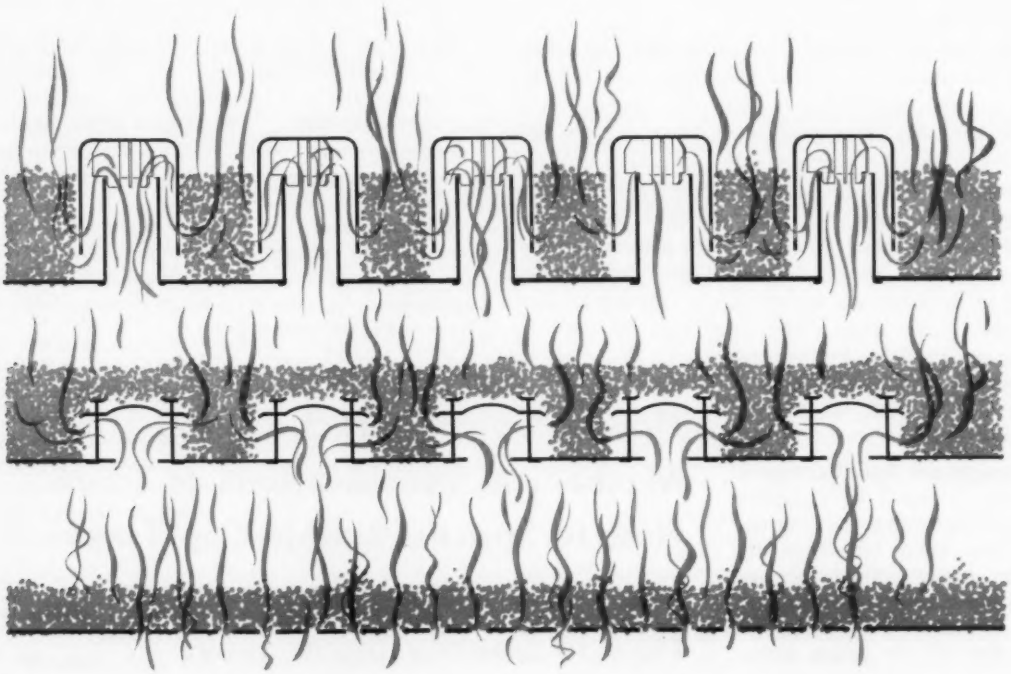
The Author

G. T. Atkins
Foster Wheeler Corporation
Baytown, Texas

THE STEPS to be taken when specifying fractionating trays follow much the same course as the job itself. Beginning with the initial design concept, the steps progress through to the final testing, and acceptance of the installation. When the job goes smoothly along a familiar path, the arrangement and scope of the work to be done can be set up with very little difficulty and there is a clear-cut division of responsibility between the engineer who prepares the specifications and the vendor who supplies the trays.

There are various general types of specifications with somewhat different objectives. Therefore, it is necessary first of all, to examine what each intends to accomplish.

Types of Specifications. Specifications are the formal means of transmitting engineering information between the parties. Now while it is true enough that they are concerned with process requirements and have some highly technical aspects, and that they are written by engineers and for engineers, it is also true that this is



TOWER										
SERVICE										
SPECIAL SKETCH NUMBER (WHERE REQ'D)										
OPERATING CASE										
TRAY NUMBERS										
LOADING POINT										
TYPE AND NUMBER OF TRAYS										
TOWER DIAMETER										
TRAY SPACING										
NUMBER OF PASSES										
ALLOWABLE PRESS. DROP PSI PER SECTION										
VAPOR LOAD: #/HR.										
VAPOR LOAD: MOL. WT.										
VAPOR LOAD: TEMP °F										
VAPOR LOAD: PRESS. PSIA										
VAPOR LOAD: COMPRESSIBILITY FACTOR										
VAPOR LOAD: CU. FT./SEC.										
VAPOR LOAD: DENSITY #/CU. FT.										
LIQUID LOAD: #/HR.										
LIQUID LOAD: SP. GRAVITY (HOT)										
LIQUID LOAD: TEMP. °F										
LIQUID LOAD: VISCOSITY (HOT)										
LIQUID LOAD: GPM (HOT)										
OPERATING RANGE MAX. %										
OPERATING RANGE MIN. %										
MECHANICAL DESIGN: SPECIFICATIONS										
MECHANICAL DESIGN: MATERIAL AND THICKNESS										
MECHANICAL DESIGN: DECK										
MECHANICAL DESIGN: CAPS										
MECHANICAL DESIGN: RISERS										
MECHANICAL DESIGN: DOWNCOMERS										
MECHANICAL DESIGN: BOLTING										
MECHANICAL DESIGN: SUPPORTS										
MECHANICAL DESIGN: VALVE ASSEMBLY										
CORROSION ALLOWANCE										

REMARKS:

TRAY SUMMARY

CUSTOMER / REFINERY

UNIT / LOCATION

FOSTER WHEELER CORPORATION
666 FIFTH AVE.
NEW YORK

SHEET | OF
DATE
REVISION
CALCS. BY
CONTRACT NO.

aside from the main purpose, which has to do with the satisfactory consummation of a commercial transaction. Specifications are good when they lead to a meeting of minds; they are inadequate if they fail to do so. The engineer prepares the specification with the intention that all of the provisions will be clear to the vendor and acceptable to him. If the engineer intends to purchase such and such an amount of performance, leaving to the vendor the means whereby this is to be accomplished, then this should be plainly stated and clearly understood. But if it is specific metal tray shapes and sizes that the engineer means to call for, and if the design comes from his own organization rather than that of the vendor, the latter may not be able to rate these trays, in his best judgment, to exactly the performance which the engineer would like to get.

A duty specification defines the vapor and liquid rates, and the densities. This is ordinarily sufficient information to establish the size and detail of the trays.

An equipment specification describes the trays; the number required, the diameter, the vertical spacing, and probably also the downcomer dimensions, the free area through the vapor passages, and much other detail.

Any or all of the following matter might logically find its way into the composition of the specifications:—the process duty and performance required, the hydraulic limitations, the kind of equipment and its arrangement, the prevailing design standards, and the conditions relating to acceptance. These elements do not all carry the same weight from one job to the next, because in one job the emphasis may be put upon a performance-result to be attained while specifying very little as to the means for getting this result; whereas in another job under different circumstances the physical equipment becomes all-important and is minutely described, but the duty may be either nominal or quite vague and indeterminate. However, these cases are the extremes. When the engineer and the vendor are in reasonably close agreement in their estimates of performance, the specification of both duty and equipment can be reconciled.

Duty-Equipment Specification. If an apparent conflict is pointed out by one of the suppliers to whom the inquiry is sent, so that it seems as if the specified duty does not match up with the equipment called for, then it will be necessary to amend the specification. The specifications may need to be relaxed in one place or another as by changing either the design vapor rate or one of the major tray dimensions. But after the specifications have been amended, the duty and the equipment may then truly correspond to each other so that the amended specification is consistent throughout. This is how specifications can wind up with both vapor rates and tray diameters fixed.

But more often than not, when both these things are specified, that is, the rates as well as the dimensions, it is because the engineer started out to specify one or the other; but then found out during discussion with vendors that the additional descriptive matter could be put in to advantage, and without getting into any real difficulties. So let us keep in mind that in addition to the pure duty specification, and the pure equipment specification, there are these intermediate cases in which both the duty is specified and to some degree the equipment also.

Existing Services. The reason for putting new trays in an existing tower might be (1) to secure better performance with respect to capacity or efficiency, or (2) be-

cause of deterioration caused by corrosion, etc. In the former case a duty specification would seem appropriate, in the latter an equipment specification; but actually, it may turn out to be a choice of where to place the emphasis. In either of the cases the vapor and liquid rates should be stated; and likewise in either case the designs can start with a certain number of fixed dimensions; the complete story, if put into the specifications, will permit vendors to offer more advantageous designs better suited to the proposed service. But it should be perfectly clear in the engineer's mind, and likewise in the specifications, just what the essential requirement really is. It may be enhanced performance. Or it may be another 10 years of service life.

Under what circumstances is it desirable to duplicate an existing unit or extrapolate the size and design for the new unit from an existing similar service. If there is a good saving in time, and in the engineering expense, then it might be a good idea to consider reordering an existing design. In the long run, the vendors, too, must include in their quoted prices the cost of engineering and overhead as it is incurred. If the cost per square foot of tray area for the small orders is not to get entirely out of line, then the time spent on engi-

OUTLINE FOR A FRACTIONATING TRAY SPECIFICATION

DUTY	
Service	Name of Unit, Vessel, Service.
Flow Changes	Tray location; rectifying/stripping section, pump-around, absorber, stripper. Rate variations, tray-to-tray. Rate fluctuations: vapor, liquid, to column. Rate controls: feed, reflux, heat input. Operating range, maximum/minimum.
Design Vapor Rate	Lb. per hr., or cu. ft. per sec.
Net Liquid Rate	Lb. per hr., gpm, or cu. ft. per sec.
Operating Conditions	Operating Temperature, pressure; Composition, avg. mol. weight; Gas law correction factor used; Vapor density, lb. per cu. ft. Liquid sp. gr. at 60°F Liquid density, at operating temperature. Impurities; corrosive, fouling, foaming; solids, sediments, colloids, emulsions; abnormal viscosity, surface tension.
PERFORMANCE	
Flooding	Percent of, at design rates, estimated.
Entrainment	Weight percent of vapor, estimated.
Separations	Required recovery, which components. Purity of product; distillate, bottoms. Tray efficiency. Equilibrium data.
HYDRAULICS	
Vapor Velocity	Superficial; over-all, local, slot, at minimum free area.
Pressure Drop	Over-all or per tray; if essential.

HYDRAULICS—Continued	
Downcomers	Clear liquid velocity, top/bottom. Residence time, top/bottom. Exit velocity, through clearance.
Weirs	Inlet weir and static seal, if required. Outlet weir, height, loading, crest; foam baffles, settling area. Intermediate weirs, side strips, deflectors.
Holdup	Limitation, max/min, if required. Allowable leakage at low vapor rate. Out-of-level tolerance, process design.
EQUIPMENT	
Tray Devices	Bubble caps; size, dimensions, drawing. Sieves; hole size, centers, free area. Proprietary; type, special features.
Arrangement	Vessel drawing, elevation; tray spacing, tower ID; nozzles, pipes, pans, sumps. Tray layout; arrangement of downcomers, caps, sieves, weirs, baffles, blanking strips, etc.; as required.
Mechanical	Design temperature, loading, deflection. Materials, corrosion allowance, thickness. Clearances, tolerances, fit, leakage. Gaskets, bolting; size, centers. Manways, tray ways, access, removability.
Fabrication	Approval of drawings, extent of detail. Shop inspection, shop assembly. Parts and extras included; stock required. Protection in transit, storage; loss, damage, rust and deterioration.
Installation	Supervision; crafts, manhours. Field inspection.
Warranties	Mechanical defects, make-good. Performance testing, Vendor's liability. Confidential matter, patents.

neering should be reduced in some relation to the size of the trays. And if the inquiry for a small order is limited to a single vendor then he, at least, can plan on a return on the design time, and can afford to be more thorough than if the inquiry were directed to several vendors each then having that much less expectation of being awarded the order. The other way of keeping the costs down is for the engineer to do a more complete job himself by turning out a specification that will be easy for the vendors to bid on. A close duplication of an existing design could be the cheapest and the best.

New Services. For new services, the duty comes from the process calculations, by using factors to allow for percent utilization of capacity, etc. The duty specification is then the easiest to use, and in many ways results in a smoother and better procedure. And this is very much the case in the large organizations which do these things over and over again, each job a lot like others of the past. The engineer and the vendors have worked together before, they understand each other and often find the duty specification an instrument for bringing about a division of labor between their respective organizations. There are also these other advantages: the comparison of sizes and designs, the excellent principle of getting competitively bid prices, and lastly a clear-cut allocation of responsibilities. These are the advantages of duty specifications; they are real, and they are attractive.

But the vendors don't get a blank check, not by any means. First, they will work within the limits of their own standards and rating curves, which are generally recognized to be reasonably conservative yet also realistic, being based on experience extending perhaps over many years. Next, the engineer can review the designs, either personally or with the help of a specialist, and arrive at an evaluation of the relative merit of the design being offered. Carrying this thought further, instances occur where a user restricts the design or rating in some particular because of the local operating experience and the interpretation placed on it. Suppliers of course get to know all about these preferences of the users and try to comply with them even though they are not strictly required to do so by the specification as written. For these reasons the duty specification usually results in a design which the user is going to find acceptable for the proposed service.

The purpose of the discussion thus far has been to emphasize the fact that the specification can be slanted in one direction or the opposite; and that the engineer should first of all get clear in his own mind what his primary objective really is with regard to the ultimate responsibility for satisfactory performance. This responsibility is chiefly upon the party who fixes the design, i.e., the number of trays and especially their size, style and detail; except that if a design is mutually agreed on, then the vendor can still guarantee the trays and be responsible for their performance to the extent allowed by his own independent rating. Again, after the specifications have been prepared they should be reviewed to see that they do not unnecessarily restrict the design and that they accomplish the engineer's purpose by saying what they mean and meaning what they say.

Following an Outline. The preparation of tray specifications is aided by the use of an outline. It serves the same purpose as a check list to avoid oversights and omissions. It has already been mentioned that the specification follows much the same course as the job itself, and it is therefore necessary to look a long way ahead so as to provide for the questions that might come up. Such an outline has been prepared (see box) as an illustration of things to include, or that might be included if circumstances warrant.

Not everything in the outline has to be put into every specification. For example, the components need not always be identified even indirectly, i.e., as by molecular weight or a point on the vapor pressure curve, provided however that the correct vapor density is stated.

A typical form sheet or Tray Summary such as is used in the Process Plants Division of a large contract engineering firm is shown in Figure 1. It is convenient for entering the data for a plurality of rating points of a tower or towers. Forms of this sort when used frequently and for a large volume of work tend to promote a smooth flow of information to the suppliers and also give best productivity from the engineering staff.

Process Information. Let us review the process design steps which come early in the course of the job, those directed toward setting the separations, reflux ratios and number of trays. All the complications of dealing with many components and several feed or product streams have been finally boiled down to a heat and material balance, say for each section of the tower. The upper and lower trays of each section are, in the ideal case, related by tray-to-tray calculations showing the progress of the fractionation, together with any change in the duties up and down the section. If the trays when installed do the job, taking good, bad and average operations all together in the ratios in which they occur, the performance will average out to give the same result as the original calculations. The ratio by which the high-capacity period must exceed the average should be estimated and used as the "design factor" for arriving at the design vapor and liquid rates at each loading point in the tower.

The distribution of the vapor load can shift up and down the tower (to some degree at least) as the feed composition or reflux ratio changes, so that the loadings at individual trays can change by some amount even when there is no apparent change in the feed rate or heat duty. It is the condensing sections (pump-around), absorbers, and stripping sections which have different duties from tray to tray. The situation can be foretold in the process calculations, and can also be spotted in an operating unit by a locally high tray-to-tray temperature gradient. It pays to know what design factors and vapor rates to use. The tower diameter as set by the trays at the point where the loading is highest can be held to a minimum if the tray spacing is increased there; and conversely, if the tray spacing is reduced on those other trays found to have lower vapor duties but with still the same diameter, then this results in a net decrease in the volume of the tower which may be reflected in a slightly lower cost. This is the reason for keeping a close watch on the design factors to use

when the vapor rate changes appreciably from tray to tray.

Fluctuations in hour-to-hour rates are also rather typical of many distillations. These fluctuations are less when all streams are under flow control but are magnified (relative to the average) when the stream in question is taken as the excess of one stream over another. One example to consider is the case of a large external stream undergoing fluctuations which must be accepted by a much smaller stream entering the tower, such as a partially condensed vapor feed or a preheated and partially vaporized liquid feed. If the instrumentation does not control to a fairly constant vapor rate, then the design factor must be chosen so as to give an operable process. The minimum rates as well as the maximum deserve this attention because if the vendors do not know about the possibility of the low-flow operation the trays supplied might be a high-capacity design with an unstable characteristic at low rates.

Performance. The design rates are usually quoted by vendors at some nominal percent of flooding, 85 percent being a typical figure. For pressure towers this is a good procedure because flooding actually governs the capacity that can be realized in practice. But the rectifying sections of atmospheric and vacuum towers, especially the latter, are to a much greater extent limited by the entrainment, which rapidly increases at the higher vapor rates. At the flash zone itself the entrainment can be greatly reduced by use of mist eliminators, but the problem of tray-to-tray entrainment remains. Usually when the entrainment is only about 10 weight percent of the vapor the bad effect on the quality of the distillate can be controlled by a moderate and calculable amount of reflux. If the reflux ratio is quite a bit higher, an amount of entrainment equal to 20 or even 25 weight percent of the vapor might still be tolerated; and just as before, this tolerable limit of entrainment can be found from a tray-to-tray calculation. But it is naturally difficult to make a firm guarantee of entrainment because it is hard to measure and there is not much data on commercial trays. One provision within the control of the engineer is to use design factors on both vapor and liquid rates, thus in effect increasing the reflux ratio and by an amount sufficient to overcome the loss of fractionation caused by entrainment.

Vendors will be glad to discuss the tray efficiencies that are ordinarily used in design and some of the values that have shown up in tests. But as a general matter, it might be difficult to bring all the factors that affect the actual over-all tray efficiency under the control of the vendors, or within the scope of exact prediction. Usually it is better to add a few extra trays to take care of the real uncertainties with respect to tray efficiency; and since this is for the ultimate benefit of the user, it seems proper for the engineer to recommend and include a liberal complement of trays. Because if there are too few, product quality or quantity will suffer; whereas, on the other hand, if the tray efficiency turns out to be better than a conservative estimate allowed for, the user will still enjoy the prospect of an incremental return. Since penalties and rewards are thus to the user's account, the user should take the responsibility of stating the requirements.

Specific performance is usually *not* called for with regard to separations. Neither the recovery nor the purity is ordinarily guaranteed by the tray fabricator, although in unusual circumstances the vendor might recognize a condition which he would desire to rectify as a matter of sound business policy. It is then up to the engineer, or his organization, to do the calculations or to have them done, so that the vendors do not each have to do all this work, ultimately at the user's expense. Once the vendors have been relieved of the burden of doing the separations, it is no longer necessary to put anything into the specifications about such requirements.

Hydraulics. With the engineer then having the primary responsibility for seeing that the correct separations are obtained, and with the tray efficiency tied in as an essential element of the separation, we can see how it is often decided that the tray hydraulics must be in accordance with the best practice known. It would be proper to have this reflected in the specifications. Many organizations tie down enough of the features of the tray design so that they can be sure that the hydraulics will be in a favorable range both for capacity and efficiency. The effect can be very close to calling for specific equipment, the test being how much room the vendors have left for doing an independent design and controlling the results obtained.

Equipment. If a complete duty specification is to be written, then the equipment section can be correspondingly abbreviated. In other cases a more complete description will be needed of the tray features which are to be given the preference.

The equipment section should be reviewed with special care by someone knowing the maintenance aspects, to assure that the correct parts are stocked (not too many and not too few) and that the mechanical features are all satisfactory. A field inspector can also make helpful suggestions which often lead to a better installation. ##

About the Author

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George T. Atkins, is active as a consulting engineer in the refining and petrochemical field under an exclusive agreement with Foster Wheeler Corp. He was formerly an engineering associate with the Humble Oil & Refining Co. at the Baytown, Texas, refinery. Atkins received a B.S. degree from Washington University at St. Louis, Mo., in 1929 and is a member of ASME, AIChE, and NSPE.

TRAYS

Mechanical Specifications of Trays

Hans C. Glitsch
Fritz W. Glitsch & Sons, Inc.
Dallas

A GOOD FRACTIONATING TRAY must incorporate quality of mechanical design as well as quality of workmanship. Sound mechanical design is a good investment because of savings in downtime and improved tray efficiency.

After the chemical process and metallurgical specifications have been drawn, the tray must be mechanically designed to meet these specifications. If corrosion is expected, a corrosion resistant alloy is normally specified with no corrosion allowance. Carbon steel light gage sectional trays are usually specified as 10 gage (.134 inch). This gage provides a corrosion allowance of $\frac{5}{64}$ inch for top or bottom side of tray deck. The mechanical designer must also consider additional factors such as ease of installation, provision for thermal expansion of the tray, creep stress, structural life, ease of access and maintenance, "onstream" time and safety.

The chemical process specifications may be very comprehensive including a tray layout drawing, or the specifications may be confined to tower sizing together with number of trays, spacing, vapor rate and density, liquid rate and density, and temperature and pressure at operating conditions.

The metallurgical specifications should indicate the type of material for the trays, hardware, fasteners and bubbling devices. In the interest of economy, the tray sections should be specified in sheet metal gages (usually 14 gage (.074 inch) for corrosion resistant alloys and 10 gage for carbon steel). Accessories and attachments such as clamps, frictional washers and bolting should be of the manufacturer's standards if they are acceptable or have proved their merit in service.

Deflection. The mechanical specifications should indicate the allowable deflection (normally $\frac{1}{8}$ inch) for given design load conditions at the operating temperature. This may be expressed as liquid height over the weir or pounds per square foot at the operating temperature. Also, for installation, inspection, safety and maintenance purposes, the tray should be designed to carry a 250 to 300-pound concentrated load at any point on the tray at ambient temperature.

The tray manufacturer should be expected to make a comprehensive proposal and supply adequate information and drawings for evaluation purposes. The tray manufacturer should also be required to justify his mechanical design and show evidence that such design is based on good engineering practices and that "stresses in extreme fibers" are within allowable creep stresses to insure many years of operating tray life.

Also, that sufficient fastening means are provided to prevent buckling of deck sections and excessive leakage under operating conditions. Excessive leakage is extremely detrimental to tray efficiency under certain process operational loads. Light gage trays require adequate fastener spacing to prevent deck sections from buckling between fasteners when subjected to thermal expansion. Fastener spacing beyond engineering limits increases the slenderness ratio of the tray sections since the sections act either as a column under thermal stresses or as a thin web beam that may fail due to diagonal shear or crippling.

Light gage channel supporting deck sections should be designed for shear lag and the allowable "effective" flange widths of the channel deck section should be taken into account. The support beams or trusses should be symmetrical about the horizontal or x-x axis to prevent stresses in the extreme fibers of the bottom or tension side from exceeding the tangent elastic limit as metal creep will eventually result in excessive deflection or sag over a period of time.

Manways. If the maintenance requirements are such, the specifications should indicate internal tray manways to be operable from both top and bottom of tray. Manway sections should be adequate in size but not of such proportions that their removal is analogous to removing half of the tray. The tray manufacturer should be required to supply tray installation instructions as well as installation drawings. ##

About the Author

Glitsch

Hans C. Glitsch is president of Fritz W. Glitsch & Sons, Inc., Glitsch-Monterrey, S.A. of Mexico, and Fritz W. Glitsch & Sons (Canada) Ltd. He is a graduate of Texas A & M College where he received a B.S. degree in mechanical engineering and a professional M.E. degree. A Tau Beta Pi, he is also a member of ASTE, AWS and API and a registered professional engineer in Texas. His work includes engineering design and product development in the field of light weight fractionating trays since 1936.

TRAYS

How to Specify Bubble Cap Trays

R. W. McClain
Fritz W. Glitsch & Sons, Inc.
Dallas

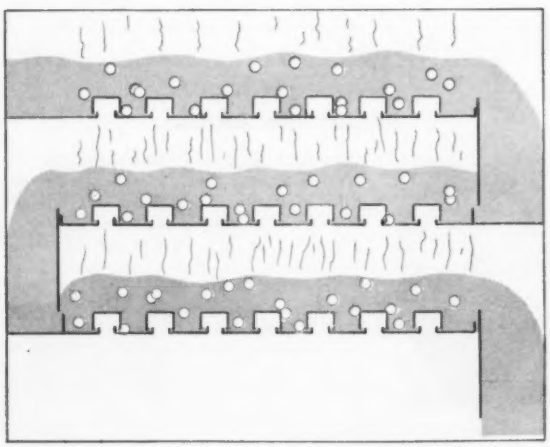
BUBBLE CAP TRAYS are nearly always specified in two ways:

- A complete process layout is specified, usually with no mention of process conditions, or
- A partial process layout is given with some leeway allowed to permit a more economcial design.

Normally, the process layout has already been determined giving the number of caps, cap spacing, downcomer area, and other pertinent data necessary to mechanically design the trays.

When specifying bubble cap trays, the tray vendor should be informed if the trays are to be used in a new unit or will be installed in an existing unit. In both cases the following information is needed to properly design the tray mechanically.

1. Type of tray preferred.
2. The exact tower inside diameter. If the tower is lined or of clad construction, this information should also be included.
3. The tower manhole inside diameter through which the tray parts must pass.
4. Orientation and elevation of nozzles including drawoffs and internal piping with respect to the trays.
5. Number of flow paths on the trays, single pass, two pass, etc.
6. Number of trays and tray spacing.



7. Analysis of material required for the trays and the corrosion allowance, if any.
8. Downcomer area or size and whether downcomers are to be vertical, or sloped, or stepped.
9. Weir height and under downflow clearance. If adjustable weirs are desired the maximum and minimum height should be specified.
10. Size of cap preferred and the type; such as round, rectangular, hexagonal, or others. Effort should be made to utilize and design around bubble cap and riser assemblies already in use in a given refinery or plant.
11. Number of caps per tray and spacing including preferred cap holddown.
12. Slot area per tray or the number, size and type of slots required per cap. There is an unlimited number of sizes and types of slots available.
13. Slot submergence and cap skirt clearance.
14. Preferred riser attachment to deck.
15. Riser area or number of risers per tray.
16. Size and height of riser.
17. Operating temperature of the vessel should be specified so that the trays can be structurally designed to suit the conditions.
18. For new units it is normal for the tray fabricator to design the tray support rings and tower attachments required for supporting the trays.
19. In case of existing vessels, there may be existing rings and tower attachments in the vessel. If these items are to be reused, their details should be included in order that the new trays may be designed to fit these attachments.
20. Also in the case of existing vessels, there may be pieces of equipment in place in the vessel such as accumulator trays, baffles, and other items that should be considered while designing the trays.
21. Preferred tray manway arrangement with respect to removability.

All of the above information may not be available in the initial stage. However, as much of the information as possible should be transmitted in order to properly design the trays. By so doing, much time can be saved and a more accurate analysis and design can be prepared for economic pricing and quoting. ##

TRAYS

How to Specify Valve Trays

Ethics forbid extending the fabricator's process service into the consulting field (providing heat balances, reflux ratios, etc.) which is foreign to tray design

G. C. Thrift
Koch Engineering Co., Inc.
Wichita, Kansas

VALVE TYPE TRAY FABRICATORS, even though of widely varied process design experience, are now dedicated to providing a tray process design service. Ethics forbid the extension of this process service into the field of consultants and contractors by providing heat balances, reflux ratios and other items foreign to actual tray design.

Information Needed by Fabricator. The tray designer-fabricator is obligated to provide an efficient tray to operate under load conditions as stated by others. His primary needs are:

A. Vapor-true volume and density
B. Liquid-true volume and density
C. Service or degree of foaminess of system
D. Preferred tray spacing.

This data should be provided for all key zones in the tower. Experienced designers should then be allowed some latitude in their highly specialized field.

With tray proportions established to suit process conditions, the mechanical specifications are next considered.

Mechanical specifications and comments supported by long experience are the primary purpose of this article.

Industry's rapid switch to valve type trays has caused no particular difficulties. Existing light gage tray specifications required only minor changes to take advantage of favorable characteristics of the valve trays.

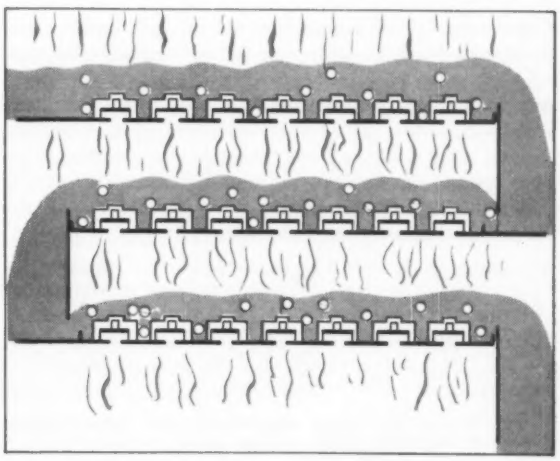
Like tubular heat exchangers, light gage tray specifications of various users have gradually become more standardized and many are convinced that this trend will continue. To this end, the following is presented as representing an extremely high percentage of the current tray requirements.

MECHANICAL SPECIFICATIONS— VALVE TYPE TRAYS

Deflection at Operating Condition

⅛-inch for 8′0″ (diameter) and smaller.

$\frac{\text{dia.}}{720}$ for greater than 8′0″ diameter.



TRAYS

How to Specify Valve Trays

Basis: 12 lbs./sq.ft. live load & 64 lbs./sq.ft. on seal pot area.

Comments: Valve type trays, with their greater minimum submergences, are less sensitive to deflection and out of level installation. Initial camber built into major beams of large towers should be considered.

Tolerance—Out of Level, Downcomer Clearance and Weir Heights—1/8-inch

Comments: Tolerances should be minimized on long weirs and particularly those with low liquid traffic. There is good evidence that a series of multipass trays out of level in the same direction will suffer serious efficiency losses.

Structural Design for Erection and Maintenance

300 lbs. concentrated load on any member.
Basis: Allowable stress at atmospheric temperature.

Comments: Such current existing loading specs vary from 200 to 300 pounds.

Corrosion Allowance

1/16-inch total for C.S. major support beams.
None required for alloy construction.

Comments: Tray support ring replacement is nil and practically all specifications are for corrosion allowance on one side only.

Min. Thickness of Tray Parts

(Trays, Downcomers & General Const.)
Non Ferrous and Alloy..... Trays —14 ga.
Minor Beams—12 ga.
Major Beams— 7 ga.

Comments: Current trends indicate an increased use of 12 ga. alloy thickness trays.

Min. Thickness of Tray Parts

(Trays, Downcomers & General Const.)
Carbon Steel.....10 ga.
Major Beams—7 ga.

Comments: There is a limited use of 7 ga. carbon steel deck thickness with alloy caps for semi corrosive service.

Support Ring Dimensions. Support ring design and widths have varied considerably among specification writers. Practically all tray supports are today edge-bent bars of varying proportions. Experience in several thousand installations proves the practicability of the following support ring dimensions:

Tower Diameter	Carbon Steel	Alloy
5'0" and Smaller	1½" x ¼"	1½" x ¼"
5'6" thru 7'6"	2" x ¼"	2" x ¼"
8'0" thru 10'0"	2½" x ¼"	2½" x ¼"
10'6" thru 11'6"	2½" x ⅜"	2½" x ¼"
12'0" thru 15'0"	3" x ⅜"	3" x ¼"*
15'6" thru 20'0"	3½" x ⅜"	3½" x ¼"*

*Notes. Use gussets under concentrated load points. Tower diameters larger than 20'0" to have special consideration.

Comments: Tower fabricators are able to accurately roll their rings to the "as built" tower ID whereas any other—including the tray fabricator, must roll the rings ahead of the requirement date and, therefore, must roll to the maximum OD as allowed by the code. This generally results in some necessary expense of tailoring the rings to the actual vessel ID. For these reasons, support rings should be purchased with the vessels per tray fabricator's details.

Here again, the replacement of rings is nil and it is almost universally specified that corrosion allowance be added to one side only.

Downcomer Bars Including Normal Corrosion Allowances

3/16" minimum for alloy.
¼" C.S. (non corr.)
⅜" C.S. (gen'l. service)

Comments: To insure fitting to tray parts, the downcomer bars should be provided by the tray fabricator. These are generally shipped to the tower fabricator for welding in place prior to tower shipment.

Replacement of these items is nil and corrosion allowances should be added to one side only.

Bolting

⅜" C.S. dia. or alloy. (Larger if necessary for long major beams.)

Comments: Some specify alloy bolting at tray manways on carbon steel trays. A few specify alloy bolting (generally Type 410) for all bolting on carbon steel trays.

Adjustable Weirs

Not required unless specified. (Usually for large towers with low liquid volumes.)

Comments: Adjustability should not be specified for valve type trays on any but long weirs with low liquid loads. The hazards of maladjustment overcome their potential benefits.

Tray Manways

Bottom removable for 3'6" and smaller θ.
Others top removable.
Maximum weight 65 lbs.
Minimum clearance 12" x 16".
Vertical align where possible.

Comments: Trayway alignment is unimportant in those installations not requiring periodic inspection, but at least partial alignment for passage of lights, hose and communication is helpful in those subject to periodic inspection.

Leakage Tests

For accumulators and drawoff wells only.
Not required for valve type tray deck areas.

Comments: The valve type tray, unlike the bell cap tray, has no net positive head of liquid on the tray and, therefore, during operation, cannot leak to the tray below. For this reason, no gaskets are required and tray leakage tests are meaningless and unnecessary. Gasket elimination has contributed greatly toward reducing installation and maintenance costs. ##

TRAYS

How to Specify Sieve Trays

Boyd A. Patton and B. L. Pritchard, Jr.
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SIEVE TRAYS can be specified either by the duty they are to perform or by a complete description of the mechanical details of the tray. The latter is normally preferred in the process industry because of (1) better knowledge of the complex materials being fractionated, (2) desire to control design safety factors, and (3) secrecy.

Because of their simplicity, sieve trays are easy to specify. The tray itself is essentially a flat piece of metal plate which has been drilled or punched with a definite number of circular holes of fixed diameter. The weirs, downcomers, and seal pans (if used) are no different than those used for other trays which utilize downcomers for liquid flow. Therefore, the only details peculiar to a sieve tray are the number and size of the holes, and that portion of the total tray area which is to be punched with holes.

Like other fractionating trays a sieve tray can be specified by stating the duty it must perform, with the manufacturer making the detailed design calculations; alternately, the specifier may design the trays and submit the equipment design details to the fabricators for bids.

The Duty Specification for a sieve tray describes the expected liquid and vapor loadings on the tray, the physical properties of the liquid and vapor, the operating conditions, and the material of construction. An outline which can be used as a guide for the preparation of a duty specification is shown in the Table titled Outline for Specification for Fractionating Trays in "How to Specify Fractionating Trays" by Atkins (Page 86, this report). Since the outline can also be used for the preparation of an equipment specification, some of the items dealing with specific tray details should be omitted. For example, most designers have their own opinions or standards with respect to the hole diameter and minimum hole pitch, but these items should not be specified in a duty specification. To do so would defeat the purpose of the duty specification which is supposed to allow the specifier to take full advantage of a manufacturer's design know-how and tooling standards.

The Equipment Specification for the sieve tray column completely describes the trays—the number required, the diameter, vertical spacing, downcomer dimensions, plate thickness, hole diameter, hole spacing limits, total number of free and open holes to be punched in the tray, number of holes (if any) which are to be blanked, dimensions of the calming zones and the location and dimensions of manways, support bars and support rings. This type of specification is frequently used in the process industry for the following reasons: First, the mixtures to be fractionated usually are relatively complex and non-ideal, and the customer frequently has a better knowledge of the materials being handled. Second, it may be advantageous for the customer to exercise internal control over the magnitude and location of all safety factors used in the design. Finally, the customer's desire for maximum secrecy may preclude his supplying the manufacturer with any information which might conceivably be used to identify the materials being fractionated.

SPECIFICATION DETAILS

Choosing The Hole Diameter to be specified is one of the designer's first considerations. This is one of the areas in which individual experience plays an important part. There are two widely diverse feelings in the industry. Some designers prefer relatively large holes (½ to 1 inch in diameter). While we have not had experience with larger holes, they are probably preferred for the following reasons: (1) trays punched with larger holes may be cheaper because fewer holes are required; (2) the allowable tray thickness is greater so corrosion allowance can be built in; and (3) larger holes are less susceptible to fouling in dirty services.

On the other hand, many designers feel that the holes should be as small as practical because experimental work has shown that smaller holes provide a greater degree of mixing and a wider range of operating stability. Since drilling is more expensive than punching, it is usually not practical to use a diameter so small that the holes must be drilled. For a given tray thickness, the mechanical limitations of punching fix the minimum hole diameter. For punched trays of copper alloy or carbon steel the minimum hole diameter which can be punched is equal to the tray thickness; for stainless steel trays the hole diameter must be 1½ to 2 times the tray thickness.

Even with these limitations there are very few cases for which 3/16 inch diameter holes will not be equal

to or greater than the practical minimum. Consequently, we feel that 3/16 inch diameter holes should be used in all cases with the possible exception of columns for high vacuum service. For clean, high vacuum services we recommend that ⅛ inch diameter holes be used if there is no significant increase in cost. The extremely low pressure drop requirements of high vacuum columns call for low weir heights which decrease the contact time between the liquid and the vapor. Therefore, the smaller holes are preferred since they help to compensate for the reduced contact time by providing greater mixing.

Calming Zones on the inlet and outlet sides of the tray are necessary to provide calming of the liquid on the inlet side and the disengaging of vapor on the outlet side. The exact width of these zones is somewhat arbitrary but in general a tray less than 5 feet in diameter should have zones 2 to 4 inches wide on each side and trays greater than 5 feet in diameter should have zones 4 to 6 inches wide on either side.

Either Recessed Seal Pans Or Inlet Weirs may be used with sieve trays. There is little difference in fabrication costs between the two, and the recessed seal pan has the advantage that a narrower calming zone is required for elimination of impact head and possible subsequent weepage on the inlet side of the trays. If seal pans are specified, the bottom of the downcomer should extend below the tray level about one inch to provide a good liquid seal. Additionally, the cross-sectional areas for liquid flow at the bottom of the downcomer, between the downcomer and the bottom of the seal pan, and the up-flow area of the seal pan should be as nearly equal as possible in order to balance the pressure drops.

The Total Number Of Free And Open Holes required in a tray is fixed by the expected maximum and minimum liquid and vapor loading on the tray. This number of holes must be fitted into the area available for holes. This area is determined by subtracting the areas occupied by the support rings and bars, manways, down-comers (on both the inlet and outlet sides of the tray), and calming zoles from the inside cross-sectional area of the column.

Experimental data show that hole pitches (center to center distance) smaller than 2½-hole diameters or larger than 4-hole diameters should be avoided. The designer should make a rough calculation to determine if at least the specified number of holes can be punched in the area available for holes without exceeding the hole pitch limitations. However, it is generally more satisfactory to specify the hole pitch limits and not the exact hole pitch unless the standard punching patterns of the individual fabricators are known. Specification of a non-standard pattern often increases the cost of trays.

If the number of holes which can be punched in the area available without exceeding the hole pitch limitations is equal to or greater than the required number, the tray design is essentially complete. Excess holes on the tray can be blanked by tack welding narrow strips of flat plate over them. These blanking strips should be scattered across the tray and should be oriented perpendicular to the liquid flow path.

If there is not enough area available for punching the required number of holes, there are several ways to overcome this. Sloped downcomers rather than straight downcomers can be specified; the calming zone area and/or the downcomer open area can be reduced; or, as a last resort, the column diameter can be increased.

Varying Vapor Rates throughout the column will result in varying hole area from tray to tray since the pressure drop per tray should be reasonably constant over the entire column. It is normally better to punch all trays with the maximum number of holes required since this is easier for the fabricator to do. The excess holes on the trays can be covered with blanking strips which, incidentally, can easily be removed at a later date if necessary.

Miscellaneous items to be specified for the sieve tray include the degree of levelness of the tray and the care to be used in punching the holes. There is no appreciable hydraulic gradient in a sieve tray column and with a reasonable outlet weir height (1½ inch to 2 inch) a tray levelness tolerance of ±⅛ inch should be adequate for good tray performance and yet not place an unreasonable restriction on the fabricator. On the other hand, if the tower service (perhaps due to high vacuum and very low pressure drop requirements) requires very low outlet weirs (0 to ½ inch) the levelness of the tray assumes greater importance and the tolerence should be held to ±1/16 inch. As far as punching the holes themselves is concerned the manufacturer should be required to make sure the holes are of consistent cross-section, that the tray does not warp or buckle, and that any burrs resulting from the punching are ground smooth. Normally, because it is cheaper and easier, the fabricator will set his dies to punch completely across the trays in such a manner that holes are punched in that area which laps over the support ring. However, in a service where active crevice corrosion is likely to be present a punched diameter should be specified so that the inactive holes will not be located over the support ring. # #

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Automatic Blending Lives Up to Goal

This case history shows automatic gasoline blending to be superior to batch or partial onstream blending. See how Sohio was rewarded for incorporating automatic blending in its Toledo refinery

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Toledo, Ohio

SOHIO'S GASOLINE BLENDER is certainly proving its worth. Capital savings of about $574,000 were realized at the time of installation. Thereafter, dollar dividends in quality control were obtained because components could be maintained to within 0.1 percent of the desired blend.

Part of Sohio's new Toledo, Ohio, refinery since 1958, the automatic blending system is exceeding all design expectations. Blending time is reduced to 2 or 3 hours. Octane give-away is held to within 0.1 octane number and Reid vapor pressure to within 0.2 psi of maximum. Also less process labor is required, and mechanical failure of the blender has caused no pipe line shutdowns.

All of these improvements in plant operations have not come without some debits. For example, more constant and costly laboratory vigilance is required. Also instrument maintenance expenses are higher ($7,921 during the first year of operation).

What Is Expected of the Blender. Controlling the quality and quantity of a refinery's most important product makes gasoline blending one of the most important functions of a refinery. Further emphasizing its importance is the fact that tetraethyl lead represents from 9 to 15 percent of a refinery's material expenses; second only to fuel in the dollar magnitude of the blending expense.

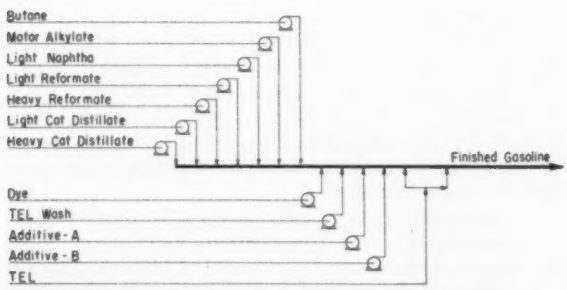

FIGURE 1—Each component and additive is pumped by a separate component pump to the blender, through a strainer, positive displacement meter, and control valve to a common header.

Blending 42 percent of Sohio's motor gasoline makes the operation of the blender a key operation of the refinery. Not only does it blend all the regular grade gasoline for the surrounding geographical area, but it blends all the premium gasoline for a large portion of Sohio's marketing area.

The blender must handle blends varying in composition from 4 to 6 major components and from 2 to 4 additives, dye, and TEL wash. The seven major components used to blend motor gasoline are as follows:

- Light cat distillate
- Heavy cat distillate
- Light reformate
- Heavy reformate
- Light hydrogenated naphtha
- Motor alkylate
- Butane

In the case of each of the first five components, two tanks are in each component service. While one tank is being used as a rundown tank, the second tank is blocked-in, mixed, tested, and used for blending. Then the tanks are reversed so that the second becomes the rundown tank and the first is available for blending. The consistency and relatively low production rate of motor alkylate permit storing it in only one tank. Blending butane is stored in one sphere because of the high capital cost of duplicate spheres and its relatively low production.

The six additive tanks include a tetraethyl lead wash tank and three dye tanks, one for each of the colors of dye required. Two separate tetraethyl lead drums and systems were provided.

As shown in Figure 1, each component and additive is pumped by a separate component pump to the blender, through a strainer, positive displacement meter,

and control valve to a common header. Tetraethyl lead is injected by a slip stream, educator, and loss-in-weight scales. The heart of the gasoline blender is the flow control system.

The control system consists of an integrated control panel and equipment to translate the component, additive, and TEL percentages into correctly measured quantities to the blender header. The control board is a series of individual control panels, one for each component and additive. The master panel contains lights and instrumentation applicable to the blender as a whole. In addition, it contains the tetraethyl lead controllers. The principal operation consists of mechanically transmitting the selected component percentage figures for each panel into actual quantities of flow through control valves. The same percentages are maintained regardless of the flow rate of the total blend. A simple computer mechanically maintains the ratios by means of a differential gear assembly and meter feedback.

Gasoline leaving the blender is on-specification. Normally it flows to one of three 40,000-barrel surge tanks. One tank is in premium service, one in regular, and one in housebrand. These tanks provide surge capacity to even out varying pipe line rates and storage capacity for small deliveries.

Pipe line rates vary between 900 bph to 2,000 bph. Pipe line batches vary from 10,000 barrels to 150,000 barrels. A typical delivery schedule is shown in Table 1.

Weighing the Advantages for Automatic Blending. Any one of three basic methods can be used in blending gasoline as shown in the accompanying box. The advantages for automatic gasoline blending at Sohio's installation are as follows:

- **Reduced tankage** was the first factor in favor of a blender. Even though the blender was built in an existing tankfield, the estimated capital cost for batch blending was higher than for an automatic blender as shown in Table 2.

The primary difference was the cost of the blending tanks. The cost of the batch blending tanks was equal to the cost of the continuous blender. This was the primary justification for a continuous blender.

- **Faster blending** is a second factor. Batch blending requires four or five days blending time after the pumping order is received from the pipe line until the finishd gasoline is available for delivery. With an automatic gasoline blender, time is not needed to fill mixing tanks, agitate their contents, sample and analyze them, add the final components, remix, resample, and reanalyze. Reblending is not normally a problem.

Faster blending may be illustrated by the typical example in Table 3.

In this example, a 140,000-barrel batch of regular grade was finished at 2:30 a.m. and an 85,000-barrel batch of premium was started at 5:15 a.m. of the same day, an elapsed time of only 2 hours and 45 minutes. During each blend, finished gasoline was delivered simultaneously to the south-bound pipe line and to the local sales terminal. To duplicate this with batch blending would require four 80,000-barrel mixing tanks and 4 or 5 days blending time prior to the start of each delivery in addition to the delivery time.

- **Better quality control** is a third factor. The blender is more accurate than are existing sampling methods, existing laboratory techniques, and mathematical calculation programs.

A simple blend which was typical of the blends during the start-up period is shown in Table 4.

Every component is within 1/10 of 1 percent of the desired blend. Every additive is within 1/100 of 1 percent of the desired blend. This accuracy is superior to the sampling and testing techniques employed to analyze the finished product.

A corollary to better quality control is reduced quality giveaway. Quality specifications must be met but not exceeded. Reid vapor pressure should be maximized so that lower value butane can be upgraded. Tetraethyl lead expense is 85 percent of the expense of gasoline blending. Tetraethyl lead represents anywhere from 9 to 15 percent of the refinery's material expenses. It is

TABLE 1—A Typical Delivery Schedule

DAY	10" Pipe Line	Local Sales Pipe Line
Friday	32,000 bbls. Premium	3,000 bbls. Regular 3,000 bbls. Premium
Saturday	3,000 bbls. Premium 29,000 bbls. Regular	
Sunday	28,000 bbls. Regular	6,000 bbls. Regular
Monday	46,000 bbls. Regular	11,000 bbls. Regular 6,000 bbls. Premium
Tuesday	11,000 bbls. Regular	6,000 bbls. Premium 4,000 bbls. Regular

TABLE 2—Capital Costs for Blending

Classification	Batch Blending	Gasoline Blender
Instrumentation	$ 30,000	$250,000
Electrical	124,000	70,000
Building	5,000	25,000
Pumps	45,000	18,000
Extra Tankage	585,000	0
Piping	200,000	150,000
Painting	10,000	8,000
Contingency	200,000	104,000
Total	$1,100,000	$625,000
Difference	$ 574,000	

TABLE 3—Typical Time Required for Blending

GRADE	Batch Size, Bbl.	Blending Time, Hrs.
Regular	140,390	86¼
Premium	85,130	41½

TABLE 4—Typical Blend Made During Start Up Period

Component	Desired Percent	MEASURED PERCENT		
		By Tank Gage	By Meter	By Panel Totalizer
Component "A"	53.0	53.1	52.9	52.9
Component "B"	46.4	46.3	46.5	46.4
TEL Wash	0.3	0.31	0.31	0.31
Additive "A"	0.2	0.20	0.20	0.20
Dye	0.1	0.11	0.11	0.11

TABLE 5—Summary of Typical Month of Blending

Batch Number	RVP Deviation Under Maximum, psi	Octane Number Deviation From Target
1	—0.2	+0.1
2	—0.1	—0.2
3	—0.1	+0.1
4	0	+0.1
5	—0.2	—0.1

Ways to Blend Gasoline

BATCH BLENDING

Component parts of the gasoline blend are added into the mixing tank. The finished gasoline is not available until all the components have been added and the tank is mixed. Design engineers estimated that four mixing tanks, each having a capacity of 80,000 barrels, would be needed to blend this refinery's motor gasoline. The capital cost of mixing tanks alone was estimated at $600,000.

PARTIAL ONSTREAM BLENDING

All or most of the components are added simultaneously into the mixing tank at a desired ratio, but are stopped short of the total quantity desired. Laboratory testing determines the final adjustments and additions. The tankful is released only after a final mixing and subsequent testing. The advantages of partial onstream blending over batch blending are, first, blending time is reduced, and, second, fewer mixing tanks, pumps, and lines are required.

Sohio utilizes a third method

CONTINUOUS AUTOMATIC BLENDING

All gasoline components, additives, and tetraethyl lead are added simultaneously in the line so that at any given moment, finished on-specification gasoline is available from the blending line.

the most expensive material, outside of crude oil, that a refinery purchases. Therefore, octane should be kept on target. Some of the greatest profits that can be realized in refinery operations are obtainable by maximizing butane in gasoline and by rigidly controlling tetraethyl lead costs.

A summary of a typical month blending is shown in Table 5. The weighted RVP average was 0.11 psi under maximum allowable. The largest deviation was 0.2 psi. The weighted average octane was exactly on target. The largest deviation was 0.2 numbers. Thus, the blender is performing well within the precision of laboratory testing.

TABLE 6—Breakdown of Maintenance Costs

CLASSIFICATION	Dollars
Instrument Maintenance Labor	3,866
Instrument Maintenance Material	4,055
Maintenance General Labor	3,456
Maintenance General Material	3,582
Total Maintenance Expenses	14,959

• **More flexibility** and reduced finished gasoline inventories are inter-related factors favoring a blender. Inventories are maintained in component tankage. Less finished gasoline need be stored to meet pipe line requirements. Unfortunately pipe line schedules do change. Blender runs can be altered more easily to meet changing pipe line schedules.

• **Vapor losses** are reduced. In batch blending, tank agitation and multiple transfers cause butane and other light hydrocarbons to be lost. In continuous blending, the butane remains in the sphere or spheroid until it is injected into finished gasoline, usually on its way to the pipe line. This continuous absorption of butane into finished gasoline minimizes its loses.

• **Process labor** is reduced. One man per shift costs approximately $28,000 per year in wages alone. Overheads and benefits are extra. Toledo's pumping department is manned by only four men per shift. Without a blender one or two additional men would be needed per shift. Other comparable refineries have six men per shift. The gasoline blender is a contributing factor, but not the only factor, to the reduced manpower.

• **Mixers omitted** from the three finished gasoline tanks is one anticipated advantage that did not materialize. The mixers were subsequently added. When they are not running, a variance in the vapor pressure of samples taken at the pipe line station is observed. It is believed this is caused by stratification in the component storage vessels in general and in the butane sphere and lines in particular.

• **Reduced utility cost** was another advantage of a blender that was not realized. Since multiple pumpovers were to be eliminated, mixing was to be reduced. The utility cost reduction was not realized, however, because of operating mixers on the finished gasoline tanks and operating all the component pumps at low, and hence inefficient, rates.

A Continuous Blender Has Some Disadvantages. Design engineers originally believed that there were three disadvantages of a continuous blender. A year's experience tells us that there are actually four permanent disadvantages and two temporary ones:

• **Maintenance costs** are undoubtedly higher for continuous blending than for batch blending. Comparing the expenses of an installed, operative system with one that was never installed nor operated is most nebulous and elusive. At best, such a comparison is only directional.

During 1959, a total of 8,603,731 barrels was blended for a daily average of 23,582 barrels. Instrument maintenance and general maintenance expenses for the year were $14,959 or $.0017 per barrel. A breakdown of these expenses are shown in Table 6.

The total maintenance expense was slightly under 1 percent of the total operating expense for motor gasoline blending. This is part of the price that a refinery pays for having a gasoline blender. These figures are not all conclusive. Reviewing the same information after two or three year's blending should produce more definite conclusions.

• **Limited operating experience** is a disadvantage for the initial startup. It is a disadvantage which soon vanishes as operating personnel gain experience.

Training is obviously a prime requisite to successful

TABLE 7—Minimum Size and Rate of Blends

	Ideal	Poor Control
Blending Rate, BPH	1,500 to 4,000	< 900
Batch Size, bbls	100,000 to 150,000	<8,000

operation. Formal classroom-type training is definitely practical. Each operator was given instruction by the tetraethyl lead supplier on hazards, safety, unloading TEL cars, and operating the TEL plant. Each operator was given instructions on the blending system as a whole, and the instrumentation in particular. The contractor and the instrument supplier jointly prepared an operating instructions manual, which was read by the operators.

Experience indeed proves to be the best teacher. Assuming blending stocks are available, a start-up time of one or two months is adequate.

• **Debugging** mechanical features was a problem. In many respects, a continuous blender is like any other new process unit. Despite careful and well thought-out engineering and despite detailed checking in the field, mechanical debugging is inevitable. Like limited operating experience for startup, mechanical debugging soon disappears as a disadvantage.

The blender is a myriad of controls, switches, wiring, lights, inter-locks, and other instrumentation. Checking each functional circuit in operation was necessary and often exasperating. A well-trained, interested instrumentation group is an absolute necessity.

Other Possible Disadvantages. Three other disadvantages can be added to the original three disadvantages that were anticipated by the design engineers:

• **Constant laboratory** vigilance is required. A typical blending schedule shows that the blender operates almost continuously for five-day periods, two days of which can fall on weekends. Operations of the laboratory are not restricted to the day shift on normal weekdays. Indeed, the control laboratory must monitor the blending on a 24 hour, seven days per week basis.

How frequently must the laboratory check the blender? It can be effectively monitored by checking its RVP, distillation, and octane. The laboratory is still adjusting the frequency of their testing. A typical control testing schedule is as follows:

Distallation	Every 8 hours
Octane	Every 4 hours
RVP	Every 4 hours

This schedule is a control schedule only. Numerous other quality tests are performed to insure the batch is held within the strict specifications.

• **Susceptibility to mechanical failure** is another possible disadvantage of a continuous blender. In batch blending, finished gasoline is deliverd from a storage tank to a pipeline. Only one pump is used. In a continuous blender, however, nine pumps and a multitude of instrumentation are utilized in blending. Any failure shuts down the blender. Repairs must be made before the surge tank drops to its minimum. When repairs cannot be made so quickly, the pipe line must either change products or shut down. For example, an electrical switchgear fire caused loss of power to the butane pump. Another example was the failure of a seal in the TEL injection pump, which halted the injection of TEL. In both cases the pipe line had to switch to other products which were readily available. Possible mechanical failure is a disadvantage which must be recognized even though it is not serious.

• **The size of batches** and blending rates are important. The blender was designed for large quantities at high rates. Small blends are not compatible with an automatic gasoline blender. Some recommended sizes are given in Table 7.

The blender was designed for 80,000 bpd or 3,333 bph. Experience varifies the manufacturer's recommendation that the meters are not accurate at low blending rates. The blender runs well at low rates down to 1,500 bph. Control at a 900 bph rate is most erratic. When the pipe line rate demand is so low, the blender is shut down for a period of time while the pipe line pumps out the rundown tank, then the blender is restarted.

Batch sizes are equally important. Large, 150,000-barrel batches are ideal; 8,000-barrel batches are almost uncontrollable. Why? After the blender is started, one hour is needed to purge the sampling system of the previous run and fill it for the current run. A second hour is needed by the laboratory to pickup and test the sample. Usually the blender is then adjusted. Normally no major adjustments are made again during the run. Thus, if the batch is small in size, it would then be completed before any adjustments are made and corresponding results realized.

Conclusion. The gasoline blender is performing satisfactorily. Automatic gasoline blending is definitely superior either to batch blending or to partial on-stream blending. Faster and more flexible blending were design advantages that are being effectively realized in actual operation. Improved gasoline blending is being performed at the price of increased instrument maintenance and closer laboratory monitoring.

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Bruce B. Butler is staff assistant to the refinery manager of The Standard Oil Company (Ohio) refinery in Toledo. Having received a Bachelor of Management Engineering degree from Rensselaer Polytechnic Institute in 1948 and a Bachelor of Law degree from the University of Toledo in 1957, Butler received an Ohio professional engineer's license and was admitted to the Ohio Bar. Employed by Sohio in 1948, he was transferred to the Toledo refinery in 1952 where he held such positions as utility engineer, operating shift foreman, refinery shift foreman, startup coordinator and assistant operations coordinator. He was in charge of the gasoline blender during its startup.

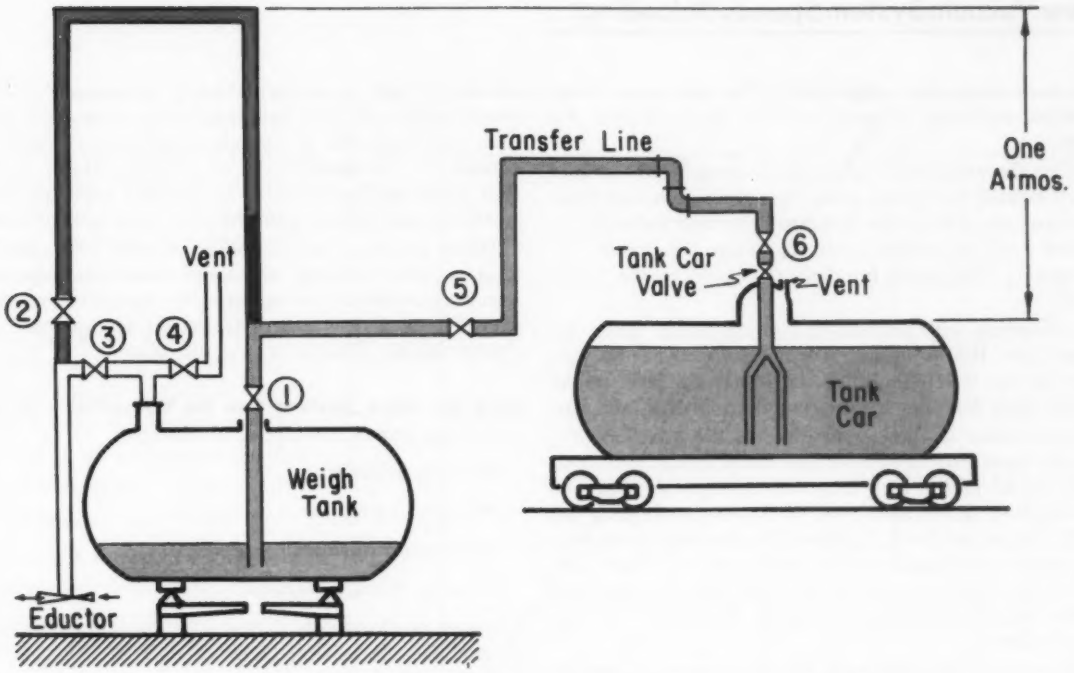

FIGURE 1—Addition of a barometric loop and one valve will speed unloading time.

New Vacuum System Speeds Unloading

Addition of a pipe loop and one valve converts conventional unloading system into more flexible system. Small initial investment can be justified by shortened transfer time

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THIS NEW VACUUM SYSTEM will save time and money in unloading tank cars through lower utility costs, lower manpower costs, less manpower requirements, increased operating flexibility and lower plant investment. The method was perfected to speed unloading of antiknock compound, although it would work equally well for handling other liquid chemicals under vacuum.

The new system is essentially a barometric loop which permits immediate priming of the unloading line. Thus it is not necessary first to spend time creating an initial vacuum in the receiving container. Now transfer can be started in only a few minutes, and will continue by gravity for the first part of the unloading cycle. Meantime, a vacuum is built gradually in the receiving vessel so as to complete the transfer. Previously it required from twenty minutes to one hour just to build enough vacuum in the receiving tank to start the transfer.

How the System Works. Operation of the system is straightforward (Figure 1). Air is removed from the weigh tank by pumping gasoline through the eductor. The first step in the operation is to start gasoline flowing through the eductor with all valves closed, except the two transfer line valves (5 and 6). Next the barometric loop valve (2) and the tank car standpipe valve are opened. When this is done the air is immediately withdrawn from the transfer line, and atmospheric pressure through the tank car vent forces the liquid up into

the loop above the weigh tank. The eductor will not produce sufficient vacuum to draw the fluid over the loop.

Next the weigh tank valve (1) is opened and the fluid starts flowing by syphon action into the weigh tank from the tank car. Once flow is started the loop valve (2) is closed and the weigh tank vacuum line valve (3) is opened. This starts building a vacuum in the weigh tank.

Unloading will proceed by syphon action alone for some time. But eventually it is necessary to have a vacuum in the weigh tank because the liquid level in the weigh tank becomes higher than that in the tank car.

Installation of the system involves the addition of a simple barometric loop and one valve, designated as 2. The height of the loop is set at the equivalent of one atmosphere. For motor mix antiknock compound this is 21 feet at sea level. The base line for any given mixing plant is the liquid level in a full tank car. Tests have shown this loop elevation is the most practical, and that under normal operating conditions draw-over of fluid is prevented.

When not equipped with the new system, a mixing plant must have a minimum of 10 inches Hg vacuum in the weigh tank before unloading can be started. This vacuum is required to lift fluid from the tank car and to force the air from the unloading line down through the weigh tank standpipe which is submerged in antiknock compound. The time required to adequately evacuate the weigh tank is dependent upon the air-handling capacity of the gasoline-driven eductor. Major factors that determine the capacity are gasoline vapor pressure, gasoline temperature, gasoline flow rates and pressures.

When antiknock compound is blended with gasoline, fluid is pulled through the weigh tank standpipe and into the gasoline-driven eductor. For simplification, however, Figure 1 does not show the liquid draw-off lines connecting the eductor to the standpipe.

How the New System Can Be Valuable. The new unloading system has several advantages:

- Lower utility costs
- Lower manpower requirements
- Increased operating flexibility
- Lower plant investment.

Steam or electrically driven gasoline pumps are used to energize the mixing plant eductor during tank car unloading. By lowering pump operating time utility costs of equipment in the 25-50 hp range are reduced. Manpower needs are also lowered. Refinery safety practice commonly requires that an operator stand by throughout the tank car unloading. Less standby time is now needed.

Greater operating flexibility is afforded by the system in that unloading may be started immediately after a mix of antiknock compound has been made with gasoline. Also if for some reason unloading is interrupted, flow can be re-established with a minimum loss of time.

In some cases mixing plant capability for unloading may not be sufficient to satisfy refinery expansion or for the introduction of an automatic gasoline blending arrangement. The installation of the new unloading system, coupled with other time-saving devices, may eliminate the need for investment in an additional mixing plant.

Figure the Time Saved. The amount of time that can be saved with the new system can vary widely among different refinery mixing plants. In some plants, savings of over an hour may be obtained in unloading a 6,000-gallon tank car. In the typical mixing plant it is expected that about half an hour can be cut from unloading time. Fortunately, the least efficient plants can achieve the greatest improvement from installation of the system.

A correlation for time savings was developed from data obtained in a full-scale mixing plant. This is illustrated in Figure 2. To use the correlation it is only necessary to know the time required to evacuate the weigh tank to 10 inches Hg vacuum. This information is easily obtained by reviewing operating records.

For example, a refiner's mixing plant operating records show 60 minutes are required in his plant to evacuate the weigh tank to 10 inches vacuum. On this basis an estimated 40-50 minutes per tank car can be saved by the new unloading system.

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The time savings potential can be related directly to the efficiency of the mixing plant eductor. In Figure 2, "Time to Reach 10 Inches Hg Vacuum" is a practical measure of eductor efficiency. A larger evacuation period would indicate a less efficient eductor. The lower the efficiency of the eductor, the more time can be saved with the new unloading system. However, if the eductor is too inefficient other steps may have to be taken—the barometric loop is not a cure-all for excessive eductor inefficiency.

The data shown in Figure 2 were obtained from unloading a standard 6,000-gallon antiknock compound tank car into an 8,000-gallon weigh tank with normal vessel elevations. A statistical analysis revealed that 9 out of 10 tank car unloadings with the new system will show a time-savings of 57 to 85 percent of previous weigh tank evacuation time.

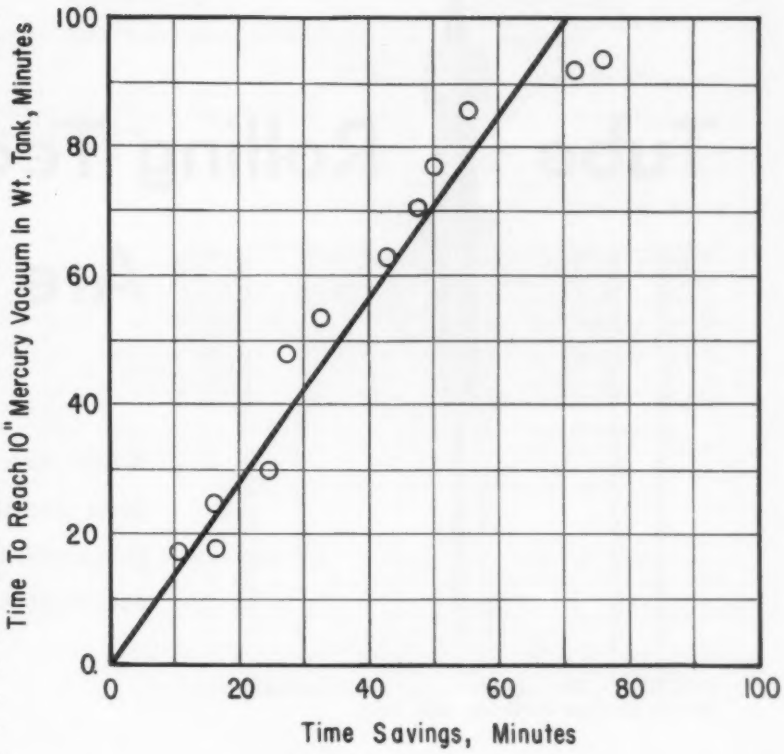

FIGURE 2—The time which can be saved with the new unloading system depends on the air-handling capacity of the eductor.

These data apply only to unloading 6,000-gallon antiknock tank cars into 8,000-gallon weigh tanks. However, this represents the most typical equipment in refinery use; about two-thirds of the tank cars in antiknock compound service are the 6,000-gallon size, and the 8,000-8,500-gallon weigh tank is the size most frequently used in refineries. Other standard tank car sizes are 3,000 and 9,000 gallons. Weigh tank capacities vary up to a maximum of 15,000 gallons.

In most of the 500 refinery mixing plants in service the difference between the elevation of the tank car and weigh tank is fairly constant, because they have been built to standard specifications. However, time-savings can also be developed for plants having unusual elevations by using calculation techniques developed during this study. A number of refiners have installed the new unloading system at their mixing plant installations. Free licensing is being offered to any interested refiner.

How Much Does It Cost? Estimates of the cost of installing the unloading system in new or existing mixing plants were made for the standard situation:

It is estimated that it will cost about $420, plus overhead and contingencies to make the addition to an existing mixing plant. The amount of overhead will vary with the method of cost accounting employed. The labor, which was the major factor in this estimate, was set at $300. When the system is installed during construction of a new mixing plant total costs are lower—about $380.

Proper Valve Manipulation Is Important. It is recommended the loop valve (2) be shut before opening the weigh tank vacuum line valve (3) when unloading is started. It was found that having the loop valve (2), open at the same time as the weigh tank vacuum line valve (3) would cause a slowing or stoppage of the flow of compound. This is due to the air that will flow through these two valves (2 and 3) over the barometric loop and down through the weigh tank liquid line valve (1) into the weigh tank standpipe. Under some conditions this can cause loss of liquid prime which, in turn, can stop unloading. Less serious, is a continuous recycle of air with two-phase flow down the standpipe, which results in slow-down of the fluid transfer. The standpipe acts as a liquid syphon leg and recycles air. These problems are simply avoided by never opening valves 2 and 3 simultaneously.

BIBLIOGRAPHY

[1] "Mixing Leaded Gasolines," Petroleum Refiner, July 1949, L. R. Fleck (Ethyl Corporation).

[2] U. S. Patent 2,856,950, October 21, 1958, "Liquid Unloading systems" to L. A. Zars, assignor to Ethyl Corporation.

Tube Rolling Techniques Are Changing

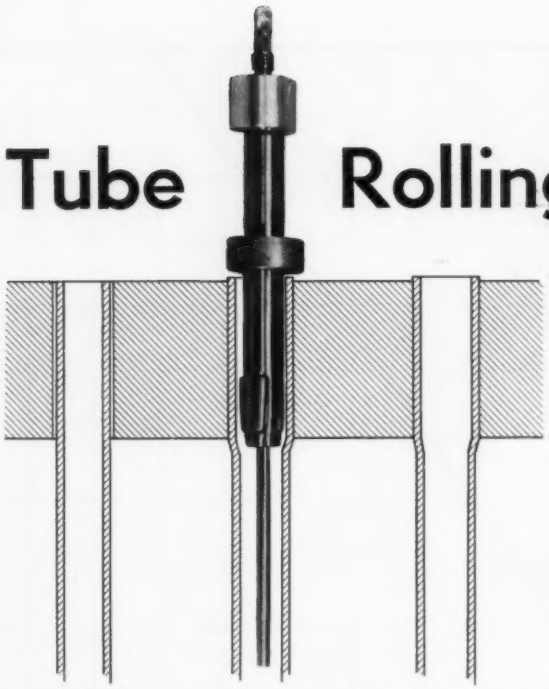

FIGURE 1—The expander is set so the straight part of the roll lies just inside the tube sheet.

Better methods and tools have been prompted by higher temperatures and pressures of heat exchange equipment

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FROM THE "feel" method of pre-World War II days to the widely used air, electric and protractive-retractive control methods of today, tube rolling tools and techniques have presented a constantly changing picture.

New concepts have been born of recent demands upon design of heat exchange equipment. Keeping abreast of these developments and principles is a "must."

Originally all tube rolling was done by feel. The job required a skilled boilermaker who was essentially a human torque-sensing device. His torque sensing consisted of a combination of feel and sound of the motor, together with observation of the depth of mandrel travel. This method was satisfactory only because it was the best available at the time.

On the other hand, the method had many drawbacks. One of these was the fact that it required a skilled operator and it took much experience to develop the "feel," especially where a variety of rolling jobs occured. Another serious drawback was the fact that physical attitude of the operator affected his "feel" and introduced another variable. Just as a package "gets heavier" the longer you carry it, so a rolling job changes over an 8-hour shift. Also a defect, in this method, is the fact that there exists a normal human tendency to over-roll a tube, just as the same tendency exists to tighten a nut too tightly and snap the stud.

A variation on the above method is the use of a motor just powerful enough at its stall point to complete the desired roll. This method also renders some success once the proper motor has been determined. However, different air pressures will affect this stall point on an air motor, as will changing electrical characteristics affect the stall point over the life of an electric motor. Thus, this method is only a partial step in the right direction.

Another old-time method of rolling was the controlled dimensional type rolling, which utilized a stop on the mandrel or a fixed dimension mandrel. Usually in this method, the expander was permitted to continue running, or dwell, after the size was reached. This rendered an ironing-out, which is believed by some to give a better roll. However, test results do not indicate any advantage resulting from this method. There is, on the other hand, a serious disadvantage to controlled dimensional rolling. Specifically, this method would be good if all tube sheet holes were equal in diameter, and all tubes equal in wall thickness, in a given tube bundle. However, this is not

TUBE ROLLING METHODS

	ADVANTAGES	DISADVANTAGES
1. Air or Electric Motor With Standard Expander (No Control)	Sometimes faster than electric control.	Requires skilled operator. Normal tendency to over-roll. Physical attitude of operator affects roll.
2. Controlled Dimension	Could minimize extreme over-rolling by less skilled operator.	Ignores variations in sizes existing in all rolling jobs. Greatly increases cost to companies that try to minimize size variations, by specifying closer tolerances. Mandrel wear greatly increased during "dwell" period. Requires over-rolling of most tubes to insure sufficient roll on tubes of greatest tolerances.
3. Electric Tube Rolling Control	Rolls each tube to correct tightness regardless of variations in tube OD and ID and tube sheet hole diameter. Does not require a skilled operator. One control will service a variety of motor sizes. Slightly greater range at each end than is available in air control. However, a variety of motors (and in some cases, controls) is necessary to achieve that range.	On most models, fluctuating voltage causes fluctuating output torque. However, a voltage regulator can be used to prevent this. Cannot be used in explosive atmospheres. Less rugged than other equipment. More accessory items required. Harder to transport and ship safely. More expensive than air controls.
4. Air Control	Most accurate tube rolling control developed thus far. Unaffected by fluctuations in air pressure. Much faster than any other control method. Very compact and lightweight. Single Unit easy to transport and ship. Quite rugged and more maintenance-free than electric controls. Some models so simple in design that nearly anyone can inspect and service in field. Have much greater range in a single unit than any one motor with electric control. Substantially less expensive than electric control. Can be used in explosive atmospheres. No electrical shock hazard.	Has slightly less range than electric control for both very light and very heavy rolling jobs. Requires portable compressor where air source is not available. More noisy than electric control but no more so than any other air motor.
5. Protractive and Retractive Control	Faster rolling, less time per tube. Better seals. Superior finish, marks in tubes eliminated. Less power required permitting lighter and faster motors, less tiring to operators. Longer expander life. Lubrication not required, therefore cleaning minimized. Adaptable to a variety of special applications.	Requires more careful measurement of tubes and tube sheet holes.

the case. In a normal bundle, the tolerances in tube OD, tube ID, and tube sheet hole diameters are such that no given size is correct for all tubes.

Nose-rolling is a variation on the above method, and incorporates the same advantages and disadvantages. In nose-rolling, a stop is likewise used on the mandrel to control its size, but the expander is inserted at this expanded size. The expander is started in the tube, then permitted to travel through the tube until the thrust collar reaches the tube sheet. One additional and serious disadvantage of this method is the fact that it puts the tube under even more compressive stress than is inherent in conventional rolling techniques.

Electronic Control. About the end of World War II, the electronic tube rolling control was released to the market, and was followed by later improved versions. Today the electric control is still widely used, and does a very satisfactory job of tube rolling control. Its operation is based on the fact that a given motor requires an increasing amount of current, at a given voltage, for an increasing amount of output torque. Therefore, by selecting the proper amperage, and limiting the motor to

that amount, the output torque of the motor can be closely controlled. This method of control is effective, since the amount of roll after metal-to-metal contact is precisely dependent upon the torque applied to the expander.

It has been established that a very small and essentially constant amount of torque is required to expand a tube in open air, and the real demand for torque starts at the point of metal-to-metal contact. It follows that a given amount of torque will expand the tubes a constant amount after metal-to-metal contact, regardless of the variable amounts of expansion required to reach the point of metal-to-metal contact.

Air Controls. Whereas the electric control is a satisfactory tube rolling control, it does have certain disadvantages as compared to the air controls that have developed. For one thing, since output torque is dependent upon voltage as well as amperage, a fluctuating voltage will result in a fluctuating output torque. Also, the electric control is limited in speed, and, of course, cannot be explosion-proof. Furthermore, it is not as rugged as the air models, and requires greater care and more frequent maintenance. At the same time, it has the advantage of being usable almost anywhere, since it requires only a 110 volt AC outlet.

The air control is approximately twice as fast as the electric control, and usually more accurate. Its greater accuracy stems from the fact that the torque-measuring device is between the motor and expander, so that fluctuating air pressure will not affect the output torque of the control. The air control has the additional advantage of being compact, lightweight and rugged, and can be used safely even in explosive atmospheres.

Whereas all electric controls function on the same basic principle, there are as many air control principles as there are air control manufacturers. In these units, torque is controlled by means of a clutch disc, by spring loading, or by the combination of a permanent magnetic force and the principle of the inclined plane. Each of these are basically sound, and it remains for the user to determine which best fits his needs from the standpoint of accuracy, capability, durability, and ease of maintenance.

Why Control The Amount Of Roll? Although there are many disagreements on how much to roll a tube, most people are in accord that there are very undesirable effects to over-rolling, and that these ill-effects are more serious than those resulting from under-rolling. An under-rolled tube can be given sufficient additional roll to properly seal it, but re-rolling an over-rolled tube simply contributes more of the undesirable effects that made it a poor roll in the first place. In the latter case, even though a seal might result, the life of the tube is definitely shortened as the result of over-rolling.

The basic purpose in rolling a tube is to obtain a good hydraulic and mechanical joint. A secondary, but equally important, purpose is to obtain a seal that is durable, resistant to crevice-corrosion, and essentially free of longitudinal tube stress. When rolling a tube, it is first expanded to the point of metal-to-metal contact, then cold-worked between the tube and sheet, to give the desired seal. This cold-working proceeds until the yield point of the tube is reached. Beyond that point, any additional expansion becomes extrusion (it has to go somewhere), with the tube extruding in both directions from the seal. Tests by various authorities, while not agreeing on the precise percentages, agree that approximately 60 to 75 percent of this extrusion goes into the bundle, with the remaining 25 to 40 percent extending out of the bundle. The result of this tube travel is to shear the sealing surface between the tube and sheet. Obviously then, the ideal seal is one that produces the desired radial stress between tube and tube sheet, but does not exceed this point sufficiently to cause objectionable extrusion. As will be shown in later paragraphs, this point occurs just beyond the yield point of the tube.

Although over-rolling the tube in the first tube sheet will not cause longitudinal stress, since the tube is free to move through the other sheet, the internal extrusion from over-rolling at the other sheet will definitely set up such stress in the tube. This compressive stress leads to stress corrosion in the bundle, frequently a major factor in shortening tube life. Since it is impossible to roll a tube such that no extrusion takes place, this compressive stress exists in all tube bundles. However, such stress, and its undesirable effects, can be minimized by controlling the roll to minimize over-rolling.

Over-rolling causes distortion of the tube sheet ligaments, which further contributes to a poor joint. Let us consider a group of tubes in which several adjacent tubes have been over-rolled. Then, as we over-roll each other adjacent tube, the resulting distortion through the tube sheet ligament further loosens the earlier rolls.

Another important consideration, while not related to over-rolling, is the length to roll the tube into the sheet. Figure 1 illustrates this consideration, by showing a properly rolled tube. This should be such that the tube is not expanded beyond the inside face of the sheet, which would make it difficult to remove the tube, and which would give a weakening of the tube where it is rolled over the edge of the sheet. At the same time, it should be rolled for the full thickness of the tube sheet, to avoid leaving a crevice between the tube and sheet, which would lead to crevice corrosion. Since the expander roll has a bullet-shaped nose, the expander should be set so that the end of the straight portion of the roll lies just inside the tube sheet as shown in Figure 1.

Step-rolling. Another point of discord in tube rolling methods is the choice of expanders for step-rolling in thick tube sheets. Actually, step-rolling is not the best way of rolling such tubes, and the method described

under "Protractive or Retractive Rolling" is far better from the standpoint of quality of roll and seal, finish, speed of rolling, and elimination of longitudinal stress. However, inasmuch as step-rolling is still rather widely used, this method should be considered. In step-rolling, some prefer to use a long roll while others not only prefer, but insist upon use of short rolls only. This choice, unfortunately, must frequently give precedence to economic factors in the selection of expanders. Simply stated, a tube requiring three steps to roll with a 1½-inch roll, can be rolled in two steps with a 2¼-inch roll.

Actually, a satisfactory joint longer than 1½-inch cannot be obtained in a single full roll, for measuring a longer joint over its entire length will invariable reveal lack of uniform dimension. Usually, the rolled tube will show a definite hourglass shape, with the heel and nose of the roll rolling larger than the center. The reason for this can be easily explained. In theory, the roll of an expander, which is inclined to the axis of the mandrel to give the feed angle, will curl around the mandrel to give a parallel roll. Actually, however, there is sufficient rigidity in the roll to make it spring up at each end, causing a larger roll at these points. This also causes the overlapping irregularities noticeable in any step-rolled tube.

Another inherent disadvantage to step-rolling should be apparent from earlier paragraphs. Specifically, since extrusion takes place in every roll, it should be obvious that step rolls, after the first step, tend to loosen the earlier rolls. This works to negate the very advantage desired from step rolling, a longer seal between the tube and tube sheet. The same disadvantage arises in double tube sheets, where again the second roll tends to push loose the joint in the other sheet.

In some thick tube sheet applications, it is customary to seal roll only the first 1½ inches, with a contact roll being used for the remainder of the sheet. Where the contact roll is made first, there is again the danger of loosening it when the seal roll is made. To prevent this, some manufacturers roll the seal roll first, then the contact roll. This is obviously the more logical approach to such a roll.

Amount To Roll The Tube. This is one of the most controversial areas of tube rolling discussion, and many persons will not take a definite stand on the subject. Conversely, many persons take a definite stand for their preference, and the disagreement between such stands is evidence that many of them are incorrect. One of the widest used, and often misunderstood criteria is the one that specifies 10 percent of wall thickness. Originally it was intended to cover an increase in tube ID, after metal-to-metal contact, equal to 10 percent of wall thickness. That is, for an 18 gage tube, the diameter would be increased .005-inch after metal-to-metal contact. Through interpretation, however, many add 10 percent for each wall (actually 20 percent of wall thickness), and some even tack on an additional several thousandths to that figure.

Ten percent of the wall thickness is sufficient for a seal on any tube, and too much on many tubes. For instance, 10 percent would be too much on a heavy gage tube, and even on 18 gage tubes of some metals, such as some aluminum alloys.[1] One exception to the 10 percent maximum mentioned above is a very thin wall tube, where 10 percent would be .002-inch or less.

The only precise method to determine the amount to roll a tube is to consider the physical properties of the tube and tube sheet. A tube or tube sheet rolled beyond its yield point will assume the new size; one not rolled beyond the yield point will tend to return to or toward its original size. Obviously, it is desirable for the tube to assume the new, or larger, size and the tube sheet to return toward its original size, so that each exerts a force upon the other, forming the grip and seal. Therefore, a tube is properly rolled in a sheet when the tube is stressed beyond its yield point, but not to its ultimate or tensile strength, and the related tube sheet is not stressed beyond its yield point. After innumerable tests and analyses on various tubes and tube sheets, a definite pattern has evolved which gives a good general rule to use in calculating the amount to roll the tube. Specifically, a tube is properly rolled when it has been expanded an amount such that its OD is theoretically .004 inch larger than the tube sheet hole. Moreover, this rule applies for all sizes and tube materials except extremely thin wall tubes and a few aluminum alloys. Obviously this rule can be applied to a given tube only when the dimensions are accurately known. When using this criterion to set a tube rolling control, for instance, several tubes and their tube sheet holes should be accurately measured, and a separate calculation made to arrive at the correct rolled size of each.

In making these calculations, do not use diameters, as they neglect the thinning effect that occurs when a tube is expanded. Rather, these diameters should be resolved to areas. Table 1 gives examples of this calculation.

Control Settings. Obviously, we must consider also some relationship between the amount to roll the tube and the control setting required to achieve that amount of roll. Many people feel that a manufacturer should specify the setting to use for a given set of conditions. Actually, the manufacturers do furnish "suggested" control settings, and these are based on settings that proved right for other users under similarly stated conditions. However, it would be hypocrisy to state these settings as a definite thing, since so many factors enter into a

Table 1—Tube Diameters Converted to Areas

	Dia. Inches	Area Sq. In.	Dia. Inches	Area Sq. In.	Dia. Inches	Area Sq. In.
Tube Size	¾	—18 ga.	1	—18 ga.	1	—12 ga.
Tube Sheet Hole Diameter	.758	.....	1.010	.....	1.008	.....
Tube OD	.750	.44179	1.000	.78540	1.000	.78540
Tube ID	.650	.33183	.898	.63335	.780	.47784
Tube Area (sq. in.)	...	.10996	....	.15205	....	.30756
Tube Sheet Hole						
+.004"	.762	.45604	1.014	.80340	1.012	.80229
—Tube Area	...	.10996	....	.15205	....	.30756
ID after rolling	.664	.34608	.911	.65135	.794	.49473

tube rolling job. Also, since many factors are preferential factors, such as amount of roll desired, length of roll set into the expander, lubricant used, etc., it remains for the user to set the control where it will render the desired amount of expansion. A good policy is to use the suggested setting as a guide, then to alter the setting either upward or downward until the proper setting is reached. In line with this, it is recommended that a group of about five tubes be chosen for setting up the control. These should be measured carefully, and a calculation made for each tube in its respective tube sheet hole. Then as each tube is rolled, it can be compared to the calculated roll, and the control adjusted accordingly. Once the control is properly set, it will repeat accurately, and give the same quality roll on each tube.

Protractive and Retractive Rolling. In tube sheets thick enough to require step-rolling, the most satisfactory means of obtaining a good seal is not by means of step-rolling, but rather by protractive or retractive rolling. In fact, this type of rolling is definitely recommended for all thicknesses 2 inches or greater and for many applications thinner than 2 inches. In this method, the entire sheet thickness is rolled in a single pass, with the expander traveling through the tube either away from or toward the operator. This method does have the disadvantage of requiring more careful measurements, but it also results in substantial time savings, usually far in excess of the small additional attention required. In use, the expander, properly sized for the job involved, is inserted into the tube to the depth desired. Then the rolls are expanded to size, and the expander travels through the tube, nose-rolling all the way. Because it is nose-rolling, the expander loading is relatively light, and the mandrel and rolls will generally outlive the conventional expander of the same size.

Furthermore, since these expanders cost very little more than standard expanders, substanial savings in tooling cost can result from use of this method. Although superior quality joints is the prime advantage of the protractive-retractive rolling method, increased speed of rolling is a very notable advantage. The time of rolling per tube is naturally dependent upon factors such as motor speed, amount of roll, material of tube, tube sheet thickness, etc., but savings in time invariably result from this method. Times for typical applications have approximated 21 inches per 20 seconds in a thin wall aluminum tube, 4 inches per 10 seconds in 18 gage Admiralty tubes, and 12 inches per 75 seconds in 18 gage stainless steel tubes.

Roll Quality. The savings in time mentioned in the preceding paragraph is only one of several advantages of retractive rolling in thick tube sheets. For one thing, the quality of roll is far superior. The roll is parallel throughout its length, and the finish is far superior to that obtained by step-rolling, usually mirror-smooth throughout. In cases where lubrication is objectionable, this method can usually be used without lubrication and without ill effects to the job or expander. Furthermore, retractive rolling eliminates the compressive stress discussed earlier. Because the tube is nose-rolled all the way, and inasmuch as the tube is free to travel in the direction it is being rolled, extrusion will work for instead of against you, in this method. As a result, the tube is rolled just beyond its yield point, and no further, with the excess material extruding out the free end. This provides the ideal seal mentioned earlier; and by observing the amount of extrusion, it serves as a secondary check on the correctness of the expander size.

Any thickness tube sheet can be rolled by this method. One manufacturer has rolled a length of 5½ foot with this method, and is now repeating the operation on a larger unit involving a 13-foot roll. Within limits, it is even possible to roll around curves with this principle.

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About the Author

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Howard A. Bach

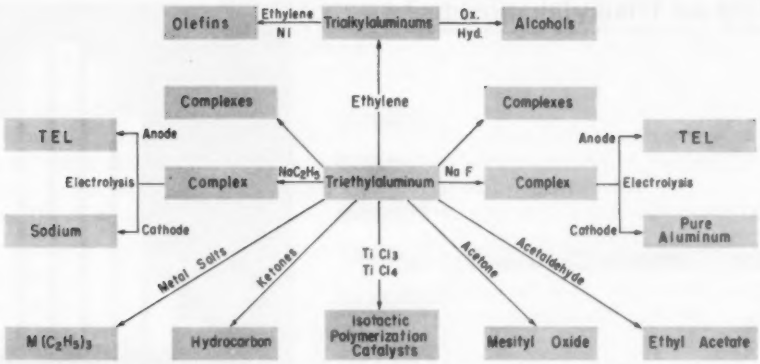

FIGURE 1—These actual and potential petrochemicals can be made from triethylaluminum.

Need More Data on Trialkylaluminums?

Here's the latest information on preparation, uses, unusual reactions and future applications of these newest petrochemicals

Lewis F. Hatch, The University of Texas
Austin

METALLIC ALUMINUM, hydrogen and olefins are the raw materials for the latest in petrochemicals. This unlikely trio is now being joined to form organoaluminum compounds—trialkylaluminum, Al $(R)_3$. They are, by definition, those compounds having a carbon-aluminum bond other than the type in aluminum carbide.

Organoaluminum compounds have been known since 1860.[1] Until recently, however, they were no more than laboratory curiosities. They were difficult to prepare and had little or no commercial value. Currently, production is about 5 million pounds per year with another 5 million pounds of capacity available.

This transformation of aluminum alkyls from the laboratory to industrial chemicals is the result of the development of an economical process for their preparation. Trialkylaluminums are utilized in the preparation of catalysts for low-pressure isotactic polymerization of olefins, in the manufacture of straight-chain primary alcohols and olefins and as pyrophoric fuels in ramjet-powered missiles and high altitude turbojet flame sustainers. The many unique chemical properties of trialkylaluminums recommend them for other uses and these are being actively explored by industry.

PREPARATION

The first preparation of trialkylaluminums was by the reaction between metallic aluminum and an alkyl halide. Neither this process nor several others were of commercial significance, however. The present economical production of trialkylaluminums dates from the observation of Hall and Nash[2] in 1938 that large amounts of ethylaluminum chlorides were formed during the polymerization of ethylene in the presence of aluminum chloride and metallic aluminum. Both Ziegler and Natta were instrumental in developing this observation into the current Ziegler trialkylaluminum synthesis from olefins.

$$2Al + 3H_2 + 6CH_2 = CH_2 \rightarrow 2Al\,(CH_2CH_3)_3$$

The process is documented by a large number of articles and patents by Ziegler and co-workers, Natta and others. The general process involves the introduction of an olefin and hydrogen into an autoclave containing aluminum activated by removal of its oxide coating and/or the presence of the trialkylaluminum being prepared. The temperatures are moderate (about 100° C) and the pressures reported vary from 100 psi to 300 atms.

Triethylaluminum and triisobutylaluminum are the two organoaluminum compounds currently produced by this process. Trimethylaluminum is also a commercial product.

CHEMICAL PROPERTIES

Trialkylaluminum compounds have been the joy, the despair and the plaything of organic chemists for many years. The lower molecular weight compounds (up to C_4) are pyrophoric and otherwise very reactive. They will react with all organic compounds except saturated and aromatic hydrocarbons. They react vigorously with water, oxygen, acids, halogens, alcohols, amines and other compounds which active hydrogen atoms chlorinated alphatic hydrocarbons, other alkyl halides benzyl halides, acid halides and many metal halides.

The aluminum atom with its ability to accept a pair of electrons imparts Lewis acid characteristics to the

Need More Data on Trialkylaluminums?

FIGURE 2—Here's one of the most promising uses of trialkylaluminum in the production of high molecular weight straight-chain alcohols.

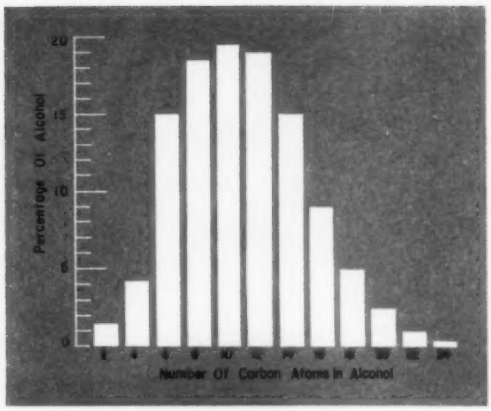

FIGURE 3—This product distribution is expected from the process shown in Figure 2 when operated by Continental Oil Co.

molecule. The trialkylaluminums consequently form complexes with organic donor molecules such as ethers, tertiary amines, thioethers, tertiary phosphines and dialkyl tellurides and selenides.[4] They also show many reactions characteristic of Grignard reagents but they are less reactive with carbonyl compounds.

They are not explosives and will not detonate or propagate flame backward through the liquid or vapor.[3]

The more important reactions of triethylaluminum, a typical aluminum alkyl, are given in Figure 1.

Polymerization. One of the most important reactions of the trialkylaluminums is their ability to promote growth reactions of olefins. The addition of ethylene to triethylaluminum takes place readily at temperatures around 100° C and pressures of about 100 atms.[4] The reaction is a progressive, step-wise growth of the alkyl chains by two-carbon increments. The alkyl groups are relatively low molecular weight and the average chain length can be controlled by regulation of olefin pressure, temperature and reaction time.[4] The higher molecular weight trialkylaluminum compounds decompose readily to form olefins with a concompitant regeneration of the triethylaluminum which may be used to continue the polymerization. The same type of reactions will take place with propylene.

An equally important reaction is the one between trialkylaluminum compounds and titanium chlorides[5, 6, 7, 8, 9, 10, 11, 12] and similar compounds[13, 14] to form catalysts for isotactic polymerization.[15] Triisobutylaluminum appears to be favored for the preparation of this type of catalyst.

Straight-Chain Primary Alcohols. One of the most promising uses of triethylaluminum is the production of high molecular weight straight-chain alcohols from aluminum, hydrogen, ethylene and air (Alfol process—Figure 2). The process is based on the work of Ziegler[16] and others[16a] and utilizes the growth reaction of triethylaluminum with ethylene to form a mixture of higher molecular weight trialkylaluminums. These are progressively oxidized by small amounts of oxygen (air) to mono-, di- and finally trialkoxides.

$$Al(CH_2CH_3)_3 + 3nCH_2 = CH_2 \rightarrow$$
$$Al\ [(CH_2CH_2)_nCH_2CH_3]_3 \xrightarrow{O_2} Al(R)_3$$

$$Al\begin{<}\begin{matrix}R\\R\\R\end{matrix} + \tfrac{1}{2}O_2 \rightarrow Al\begin{<}\begin{matrix}OR\\R\\R\end{matrix} \xrightarrow{\tfrac{1}{2}O_2} Al\begin{<}\begin{matrix}OR\\OR\\R\end{matrix} \xrightarrow{\tfrac{1}{2}O_2} Al\begin{<}\begin{matrix}OR\\OR\\OR\end{matrix}$$

The mixture of aluminum alkoxides is hydrolyzed to the desired even number of carbon atom fatty alcohols[17] and aluminum hydroxide:

$$Al\begin{<}\begin{matrix}OR\\OR\\OR\end{matrix} + 3H_2O \rightarrow 3ROH + Al(OH)_3$$

A typical product distribution is given in Figure 3. The commercial production of these alcohols is scheduled by Continental Oil Company for early 1961. The plant capacity is reported to be over 50 million pounds per year.

This process permits the production of fatty alcohols from petroleum. Prior to this development they came exclusively from natural sources such as tallow fat and coconut oil. Alcohols by this process will be cheaper and in more stable supply than the naturally-derived compounds. They will be used in the manufacture of detergents, plastics, cosmetics, lubricating oil additives, paper, textiles and emulsifiers. The straight-chain alcohols are reported to be better than the branched-chain ones in numerous applications. For example, their phthalate esters perform better at low temperatures and they are more permanent when used to plasticize vinyl resins.[18]

These alcohols may be used to produce both anionic and nonionic surfactants. The anionic detergents could be formed by direct sulfation.

$$RCH_2OH + H_2SO_4 \rightarrow RCH_2OSO_3H \xrightarrow{Base} RCH_2OSO_3Na$$

Two types of nonionic surfactants are possible from these fatty alcohols. They can form ethylene oxide adducts which will compete directly with natural fatty alcohol-ethylene oxide adducts and the oxo alcohol-ethylene oxide adducts.

$$RCH_2OH + nCH_2\overset{O}{\diagup\diagdown}CH_2 \rightarrow RCH_2O(CH_2CH_2O)_{n-1}CH_2CH_2OH$$

Compounds of this type are in competition with alkylphenols for most uses and are more desirable in many applications but are currently more expensive. Alcohols from triethylaluminum and ethylene may change this economic picture. Anionic surfactants may be obtained indirectly from these alcohols by their oxidation to carboxylic acids which in turn may be converted to alkanolamide nonionic surfactants.

The relationship between the various types of nonionic surfactants and the current production figures and predicted production figures for 1965 are given in Figure 4. Nonionics are steadily increasing their share of the total synthetic surfactant output and account for more than 25 percent of the over-all production.[19] Present production is 375 million pounds per year with the prediction of 520 million pounds for 1965.

Tetraethyllead (TEL). Tetraethyllead is made by the reaction between a sodium-lead alloy and ethyl chloride in an autoclave at 65°-75° C and 50 to 60 psi.

$$4NaPb + 4CH_3CH_2Cl \rightarrow Pb(CH_2CH_3)_4 + 3Pb + 4NaCl$$

The yield based on the sodium is good (85-90 percent) but only one atom of lead out of four is converted into tetraethyllead. Several continuous processes have been developed but the chemistry of the reaction is the same.

Various methods have been proposed to permit a more economical utilization of lead. Several of these processes involve the use of triethylaluminum. One of the earlier methods utilized the reaction between triethylaluminum and nonhalide lead compounds (lead oxide, lead sulfate, lead acetate).

$$4Al(CH_2CH_3)_3 + 6PbO \rightarrow 3Pb(CH_2CH_3)_4 + 3Pb + 2Al_2O_3$$

The conditions are mild (100°C and 100 psi) and the reaction takes place in organic solvents such as hydrocarbons, amines, ethers, esters and chlorinated hydrocarbons. This reaction permits the utilization of two out of four lead atoms. The process was subsequently modified by carrying out the reaction with lead acetate in the presence of cadmium acetate, ethyl iodide and an excess of triethylaluminum. The by-product lead is ethylated, probably by ethyl iodide and diethylcadmium which is formed by the reaction between cadmium acetate and triethylaluminum.

$$6Pb(OOCCH_3)_2 + 4Al(CH_2CH_3)_3 \rightarrow 3Pb(CH_2CH_3)_4 + 3Pb + 4Al(OOCCH_3)_3$$
$$3Cd(OOCCH_3)_2 + 2Al(CH_2CH_3)_3 \rightarrow 3Cd(CH_2CH_3)_2 + 2Al(OOCCH_3)_3$$
$$3Pb + 6CH_3CH_2I + 3Cd(CH_2CH_3)_2 \rightarrow 3Pb(CH_2CH_3)_4 + 3CdI_2$$
$$3CdI_2 + 3Al(CH_2CH_3)_3 \rightarrow 3Cd(CH_2CH_3)_2 + 2AlI_3$$

The cadmium iodide is converted to diethylcadmium by triethylaluminum. All of the lead is converted to tetraethyllead by this process.[20]

Two electrolysis processes have been proposed.[4] The original process involved the electrolysis of a triethylaluminum-sodium fluoride complex using a lead anode. Tetraethyllead is formed at the anode and pure aluminum is deposited at the cathode.

$$4NaF \cdot Al(CH_2CH_3)_3 + 3Pb \xrightarrow{e} 3Pb(CH_2CH_3)_4 + 4Al + 2NaF$$

This process has been modified by Ziegler to replace the troublesome solid aluminum at the cathode by liquid sodium.[21] The electrolyte is a ethylsodium-triethylaluminum complex formed from triethylaluminum and ethylsodium. Tetraethyllead is formed at the anode and sodium at the cathode. This process is reported to be especially suitable for small plants.[22]

Thermal Decomposition—Pure Aluminum is a by-product of one electrolytic process by which TEL may be produced from triethylaluminum. It can also be formed by the thermal decomposition of trialkylaluminums.[4] An example is the decomposition of triisobutylaluminum at 200°C to give aluminum, hydrogen, isobutylene and a small amount of other products.

$$2Al(CH_2CH(CH_3)_2)_3 \xrightarrow{200^\circ C} 2Al + 3H_2 + 6CH_2{=}C(CH_3)_2$$

The aluminum has a purity of 99.999 percent.

This process offers a possible method for gas-phase plating of metals and nonmetals with aluminum. The electrolytic process and the thermal decomposition process make it economically feasible to produce pure aluminum and to plate a variety of metal and nonmetel objects with aluminum.

Catalytic Decomposition—Olefins. Although the thermal decomposition of trialkylaluminum compounds may be used to produce olefins along with pure aluminum, a more efficient process is the catalytic displacement of the alkyl group by ethylene.[4]

$$Al[(CH_2CH_2)_nCH_2CH_3]_3 + 3CH_2{=}CH_2 \xrightarrow{Ni} Al(CH_2CH_3)_3 + 3CH_3CH_2(CH_2CH_2)_{n-1}CH{=}CH_2$$

The catalyst is colloidal nickel and triethylaluminum is a co-product. The triethylaluminum can be used in a growth reaction to produce more trialkylaluminum. The straight-chain olefins have an even number of carbon atoms and may be used for the alkylation of aromatics to produce detergents or for any other typical olefin reaction.

Propylene can be used to produce 2-methyl olefins ($RC(CH_3) = CH_2$).

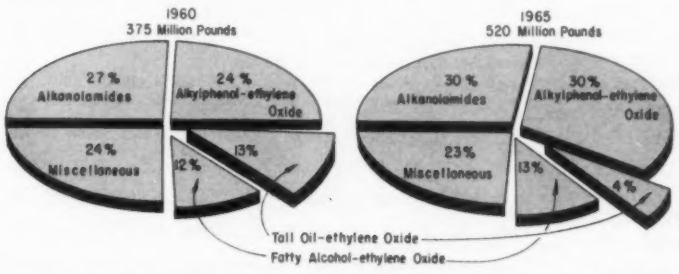

FIGURE 4—Here's how present production of nonionic surfactants looks compared with 1965 production.

Need More Data on Trialkylaluminums?

Reaction with Active Hydrogen Compounds—Paraffins. Trialkylaluminums will react with compounds containing active hydrogen atoms to form saturated hydrocarbons.

$$Al(R)_3 + 3R'OH \rightarrow 3RH + Al(OR')_3$$

Alcohols, primary and secondary amines and organic and inorganic acids may be used in this reaction.[23,24]

The higher molecular weight trialkylaluminums will react with water to form saturated hydrocarbons. Those with butyl or lower molecular weight alkyl groups react almost explosively. The reaction can be moderated by dilution of the aluminum alkyl with hydrocarbons.

Reactions with Carbonyl Compounds. Triisobutylaluminum and other trialkylaluminums are good reducing agents for carbonyl compounds, especially aldehydes.[4] The initial reaction forms aluminum alkoxides which on hydrolysis yield alcohols.

$$3C_6H_5CHO + Al(CH_2CH(CH_3)_2)_3 \rightarrow Al(OCH_2C_6H_5)_3 + 3CH_2{=}C(CH_3)_2$$

$$Al(OCH_2C_6H_5)_3 + 3H_2O \rightarrow 3C_6H_5CH_2OH + Al(OH)_3$$

They appear to react in a manner similar to that of lithium aluminum hydride ($LiAlH_4$). They are less expensive than lithium aluminum hydride and may find commercial applications in the production of special alcohols.

Triethylaluminum will reduce some ketones to hydrocarbons and condense and dehydrate others. It reacts with acetone to form mesityl oxide[25] and acts as a catalyst for the formation of esters from aldeyhdes. Acetaldehyde, for example, can be converted to ethyl acetate by this process.[27]

$$2CH_3CHO \xrightarrow{Al(CH_2CH_3)_3} CH_3COOCH_2CH_3$$

In general, trialkylaluminums react with carbon dioxide, aldehydes, and ketones to form either addition or reduction products depending on the reaction conditions.[28,29,30]

Triethylaluminum can also be used as a reducing agent in the synthesis of the carbonyls of transition metals.[26] The triethylaluminum appears to function in this reaction as a selective reducing agent for the transition metal, permitting carbonylation to occur at a rate greater than the rate of reduction to the free metal.

Other Metal Alkyls. Metals less active than aluminum can be alkylated by trialkylaluminums. An example of this type of reaction is the alkylation of led salts and cadmium salts in one of the previously described processes for the production of tetraethyllead. Boron and silicon alkyls may be produced in a similar manner.[4]

FUELS

The pyrophoric nature of the lower molecular weight trialkylaluminums combined with their high energy content makes them attractive as fuels in ramjet powered missiles and as high altitude jet plane sustainers for turbojet engines.[31,32,33] Triethylaluminum has a total enthalpy at 25° C of 20,160 Btu/lb. and its flame speed is estimated to be many times as high as that of hydrocarbon fuels.[32] This increased flame speed makes it possible to design engines for operation under more severe conditions of pressure and stream velocity than is possible with hydrocarbon fuels.

The re-ignition properties of trialkylaluminums can reduce the danger of flame-outs in turbojet engines when they are used as primary fuels, igniter fuels, or admixed with hydrocarbons jet engine fuels. Wide variations in fuel-air ratios are possible with pyrophoric fuels without combustion instability or engine blow-out.

The pyrophoric nature of the aluminum alkyls permits the elimination of external ignition systems and electric power sources. Flame holders may also be eliminated with a resulting reduction of engine length by one-third. The over-all weight of a ramjet drone using trialkylaluminum fuel may be as little as 60 percent of an equivalent liquid-fuel rocket drone.[32]

The greatest deterrent to the development of aluminum alkyls as fuels is their cost. The recent advances in processes for their production may go a long way toward reducing this disadvantage. It will be some time, however, before their use is other than for meeting special fuel requirements.

LITERATURE CITED

[1] Cahours, A., *Ann.*, **114**, 227-255 (1860).
[2] Hall, F. C. and Nash, A. W., *J. Inst. Petroleum Tech.*, **23**, 679-687 (1937); *ibid.*, **24**, 471-495 (1938).
[3] Allison Division of General Motors, "Pyrophoric Fuels," February 1, 1959.
[4] Lincoln, D. C., "Aluminum Alkyls," Hercules Chemist, **37**, 22-24 (1959).
[5] Natta, G., Pino, P. and Farina, M., *Supplemento Ric. Scient.*, **25**, 120 (1955).
[6] Badin, E. J., *J. Am. Chem. Soc.*, **80**, 6545-6548 (1958), *ibid.*, **80**, 6549-6551 (1958).
[7] Ang, F. and Mark, H., *Monatsh*, **88**, 427-431 (1957).
[8] Danusso, F., Calagno, B. and Sianesi, D., *Chim. e Industria (Milano)*, **41**, 13-18 (1959).
[9] Friedlander, H. N. and Oita, K., *Ind. Eng. Chem.*, **49**, 1885-1890 (1957).
[10] Topchiev, A. V., Krentsel, B. A., Tolchinsky, I. M. and Garnishevskaya, G. V., *Doklady Akad. Nauk. SSSR, Odtel Khim Nauk.*, **114**, 113-116 (1957).
[11] Hume, S. E., *Ind. Eng. Chem.*, **48**, 784-791 (1956).
[12] Ziegler, K., Martin, H. and Stedefeder, J., *Tetrahedron Letters*, No. 20, 12-19 (1959).
[13] Natta, G., Pino, P., Mazzanti, G. and Giannini, U., *J. Am. Chem. Soc.*, **79**, 2975-2976 (1957).
[14] Natta, G., Pino, P., Mazzanti, G. and Lanzo, R., *Chim. e Industria (Milano)*, **39**, 1032-1037 (1957).
[15] Hatch, L. F., Petroleum Refiner, **36** (4) 169-171 (1957).
[16] Ziegler, K., Brit. Pat. 804,335 (1958).
[16A] Esso Research and Engineering Co., Brit. Pat. 808,055 (1959).
[17] Continental Oil Company, "Alfol Alcohols."
[18] *Chem. Eng. News*, August 31, 1959, p. 21.
[19] *Chemical Week*, April 23, 1960, p. 114-116.
[20] *Chem. Eng. News*, April 28, 1958, p. 66.
[21] Ziegler, K., Brit. Pat. 779,873 (1957).
[22] *Chemical Week*, June 13, 1959, p. 37-38.
[23] Davidson, N. R. and Brown, H. C., *J. Am. Chem. Soc.*, **64**, 313-324 (1942).
[24] Knap, J. E., Leech, R. E., Reid, A. J. and Tamplin, W. S., *Ind. Eng. Chem.*, **49**, 874-879 (1957).
[25] Leone, P., *Gazz. Chim. Ital.*, **55**, 301-306 (1925).
[26] Podall, H. E., *J. Am. Chem. Soc.*, **80**, 5573-5574 (1958).
[27] Geiersberger, K. and Galster, H., *Z. Anorg. Allg, Chem.*, 274, 289-292 (1953).
[28] Meerwein, H., Hinz, G., Majert, H. and Sonke, H., *J. prakt. Chem.*, **147**, 226-250 (1936).
[29] Baker, E. G. and Sisler, H. H., *J. Am. Chem. Soc.*, **75**, 5193-5195 (1953).
[30] Zakharkin, L. I. and Gavrilenko, V. V., *Proc. Acad. Sci. USSR.*, **118**, 712 (1958).
[31] Simkin, D. J. and O'Brien, C. J., "Metal Alkyls as Hypergolic Fuels," Marguardt Aircraft Co.
[32] Curtiss-Wright Corp., Wright Aeronautical Div., "Ramjet and Turbojet Engines Utilizing Pyrophoric Fuels," November 14, 1958.
[33] Hardin, M. C. and Verkamp, F. J. "Pyrophorics for Aircraft Propulsion, Their Promise and Problems." Presented at the SAE National Aeronautic Meeting, New York City, March 31-April 3, 1959.

Applied Hydrocarbon Thermodynamics

Part 20: P-T-C K-Charts for Vapor-Liquid Equilibria in Hydrocarbon Systems

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WHEN COMPLETED in 1954, the generalized correlations of hydrocarbon fugacity coefficients, given in Part 19, seemed to provide a basis for preparing more consistent and complete K-value charts for hydrocarbons in mixtures containing paraffins and olefins.

DePriester[1] had published a series of hydrocarbon K charts, based on the same fugacity coefficients that had been computed by the Benedict-Webb-Rubin Equation of State and worked up into the Kellogg charts employing the molar average boiling point as a composition parameter.

In this DePriester recorrelation there were two charts for each substance, one for the vapor and one for the liquid phase, giving the fugacity coefficients as functions of temperature, pressure and molar average boiling points of the liquid and vapor phases. Two parameter charts were prepared and readings of the liquid or vapor "factor" were made by starting with b_L or b_v, going to the temperature, then to the pressure and then to the A or B scales ($A = \bar{f}^L/Px$ and $B = Py/\bar{f}^v$). These charts covered temperatures of —100° to 400° F., pressures up to 1000 psia and boiling points of —200° to +200° F.

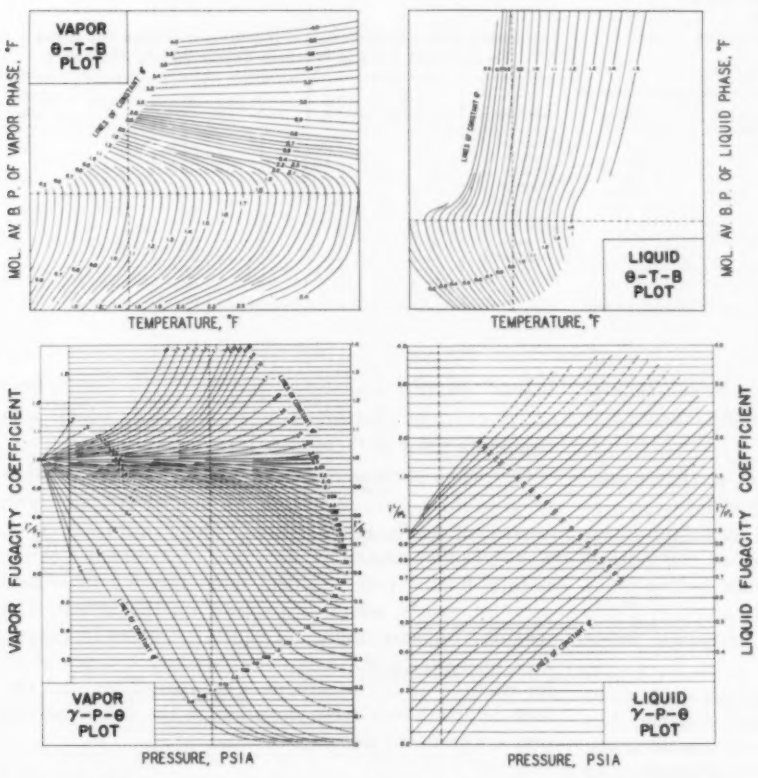

FIGURE 20.1—K-value charts from generalized fugacity coefficient correlations.

The same 12 light hydrocarbons covered in the BWR work were charted up in this manner by DePriester. By using the generalized correlations giving the fugacity coefficients as functions of T_r, P_r, and B_r this coverage could be increased, both as to hydrocarbons and conditions. This was done, obtaining similar charts for 16 hydrocarbons and wider ranges of pressure, temperature and average boiling points.

These charts, which are presented here, were tested and found to be less accurate and more inconvenient than expected. Improvements in the charts to increase their accuracy and convenience were considered but never made, because it was concluded, about this time, that the MABP was not an adequate composition-effect parameter, especially for the liquid phase. These P-T-C K-charts are intended for applications

TABLE 20.1—Boiling and Critical Points plus Constants in Vapor Pressure Equation
$\log P^{o} = a - m/T$

Hydrocarbon	T_B, °R	T_c, °R	P_c, psia	a	m
Methane	201.0	343.2	673.1	5.1761	805.8
Ethylene	305.0	509.5	742.1	5.4101	1294.2
Ethane	332.2	549.8	708.3	5.4194	1412.5
Propylene	405.8	657.1	667.0	5.4995	1757.9
Propane	416.0	666.0	617.4	5.4920	1799.1
i-Butane	470.6	734.7	529.1	5.4968	2037.5
i-Butylene	479.3	752.2	579.8	5.5656	2108.3
l-Butylene	480.4	755.3	583.0	5.5594	2109.8
n-Butane	490.8	765.3	550.7	5.5541	2153.2
i-Pentane	541.8	829.7	483.0	5.5379	2367.8
n-Pentane	556.6	845.6	489.5	5.6212	2479.4
n-Hexane	615.4	914.2	439.7	5.6830	2778.9
n-Heptane	668.9	972.3	396.9	5.7540	3068.4
n-Octane	717.9	1024.9	362.1	5.8128	3334.9
n-Nonane	763.1	1072.7	345.0	5.9170	3624.6
n-Decane	804.9	1114.7	320.0	5.9804	3874.3

TABLE 20.2—Evaluation of PTC K-Charts
Range: 0° to 450° F.
3 to 500 psia
Average Absolute Deviations from Observed Data, %
PTC Charts

Hydrocarbon	DePriester	These Charts	MIT (3)	Number of Data
Methane	5.3	6.1	34.5	33
Ethylene	1.9	2.8	9.6	4
Ethane	4.5	6.3	8.0	24
Propylene	1.9	2.0	0.8	8
Propane	4.0	4.0	6.2	31
Isobutane	7.5	4.9	8.3	8
n-Butane	4.5	6.2	8.5	22
n-Pentane	6.4	6.2	11.6	19
n-Heptane	8.1	5.6	5.5	5
Average	5	5	13	159

TABLE 20.3—Evaluation of PTC K-Charts
Range: 501 to 1000 psia
Average Absolute Deviations of Chart Values from Observed Data, %
PTC K-Charts

Hydrocarbon	DePriester	These Charts	Number of Data
Methane	6.9	7.2	21
Ethylene	2.8	5.0	2
Ethane	8.2	5.4	7
Propane	6.1	6.4	10
Isobutane	3.4	5.5	5
n-Butane	8.0	7.8	11
n-Pentane	15.6	14.4	9
n-Heptane	29.1	5.8	1
Average	8	8	66

TABLE 20.4—Distribution of Deviations of New PTC Chart Values from Data in Pressure Range 0 to 300 psia

Deviation	—15% or more	—15% to—7%	—7% to 0	0 to +7%	+7% to +15%	+15% or more
Methane	3	5	19	10	..	..
Ethene	..	2	5	..	..	..
Ethane	..	4	10	14	10	2
Propene	..	..	5	..	..	..
Propane	3	3	5	12	2	..
Isobutylene	..	..	1	..	..	..
Isobutane	..	1	3	1	..	1
n-Butane	..	4	6	5	2	1
n-Pentane	..	..	8	2	1	1
n-Heptane	..	..	4	..	..	..
Sum	6	19	66	44	15	7

TABLE 20.5—Distribution of Deviations of New PTC Chart Values from Data in Pressure Range 301 to 700 psia

Deviation	—15% or more	—15% to—7%	—7% to 0	0 to +7%	+7% to+15%	+15% or more
Methane	..	2	11	13	3	..
Ethene	..	..	1	2	..	..
Ethane	..	..	3	5	4	2
Propene	..	..	2	1	..	..
Propane	1	1	9	6	..	..
Isobutylene	..	2	1	..	..	..
Isobutane	..	..	2	5	..	..
n-Butane	1	2	5	2	2	..
n-Pentane	1	2	3	2	1	..
n-Heptane	..	1	..	..	..	..
Sum	3	9	37	36	10	2

TABLE 20.6—Distribution of Deviations of New PTC Chart Values from Data in Pressure Range 701 to 3600 psia

Deviation	—15% or more	—15% to—7%	—7% to 0	0 to +7%	+7% to +15%	+15% or more
Methane	..	1	1	7	10	2
Ethene	..	..	..	1	1	..
Ethane	..	..	4	6	3	..
Propane	..	4	4	3	3	1
Isobutane	1	..	..	1	..	..
n-Butane	1	..	1	4	1	1
n-Pentane	3	4	2	1	..	1
n-Hexane	1	..	1	..	..	..
n-Heptane	..	..	..	1	..	..
	6	9	13	24	18	5

only to paraffinic-olefinic mixtures. They should be useful in developing new correlations for high pressures and wide boiling range mixture.

Chart Preparation. The new P-T-C K-charts presented in this installment for 16 hydrocarbons were prepared directly from the generalized correlations on Figures 19.1 through 19.6 by the use of the critical temperature and pressure and the normal boiling point of each hydrocarbon. These values are given in Table 20.1 along with the constants for a simplified vapor pressure equation.

This chart preparation was handled with a minimum of engineering time by photography and drafting. The original generalized charts, which were drawn on graph paper of orange-colored grids, were photographed in such a way as to eliminate the grids but retain the black line Θ^V (or Θ^L) parameters and the $\bar{f}^V/Py$ (or $\bar{f}^L/P^o x$) scales only, as illustrated in Figure 20.1, which is a composite print of these negatives.

On prints of these negatives, new grids were ruled in to give final co-ordinates in °F and PSIA for both phases of each hydrocarbon. The conversion from reduced to specific units were made by reference to the normal boiling point, critical temperature and critical pressure values, which are shown on the charts. The resulting fugacity coefficient charts are given in Figures 20.2 through 20.33,* a liquid chart and a vapor chart for each of 16 hydrocarbons. Only paraffinic and olefinic hydrocarbons were included as the basic correlation is limited to these types.

* Only Figures 20.1, 20.2, 20.3, 20.10, 20.11, 20.22, 20.23 are presented in this article. See box for note regarding remaining 26 figures.

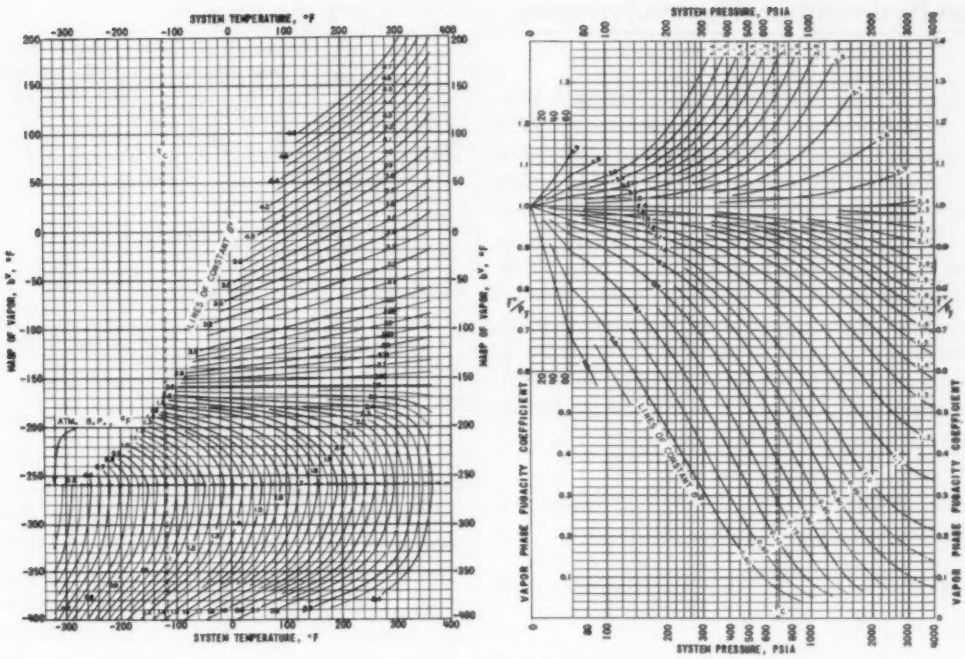

FIGURE 20.2—Methane vapor coefficient for vaporization equilibrium constants.

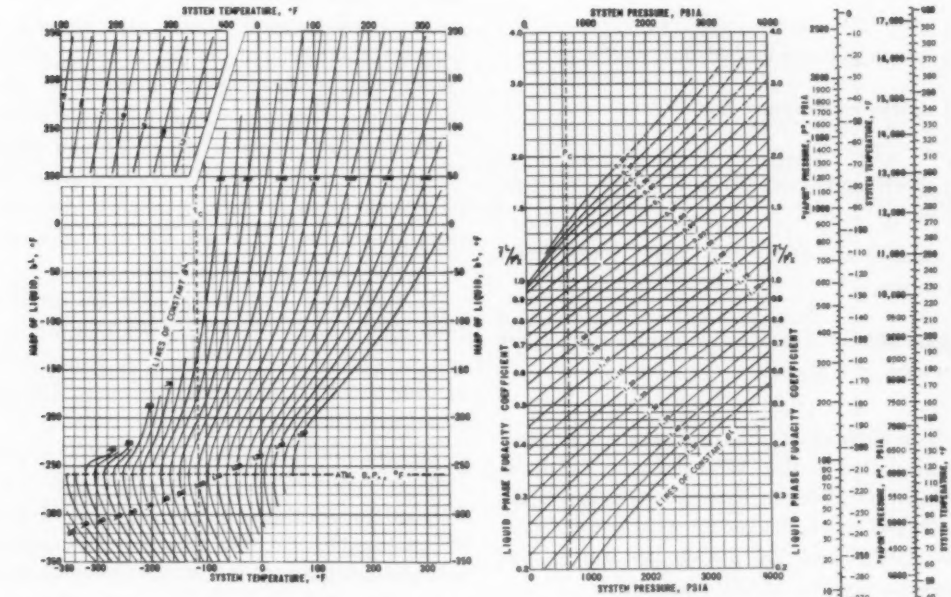

FIGURE 20.3—Methane liquid coefficient for vaporization equilibrium constants; Normal BP, $b_i = -258.7°$ F.

Follow these steps to calculate K's from charts:

1. From MABP of vapor and system temperature find Θ^v.
2. From system pressure and Θ^v find $\bar{f}^v/Py$.
3. From MABP of liquid and system temperature find Θ^L.
4. From system pressure and Θ_L find $\bar{f}^L/P^o x$.
5. From system temperature find P^o.
6. From above readings calculate $K = [\bar{f}^L/P^o x)/(\bar{f}^v/Py)]\ (P^o/P)$.
7. Find equilibrium vapor and liquid compositions from K values.
8. Compute MABP of vapor and liquid and compare with values used in 1 and 3.

The vapor pressure (P^o) values, for use with these fugacity coefficient charts, were obtained by the same method used in developing the generalized charts, Figures 19.1 through 19.6. Below the atmospheric boiling point, the values of P^o are from the API 44 vapor pressure tabulations. Above the atmospheric boiling point, the values of P^o were obtained by assuming a straight line relationship on log P^o versus $1/T$ scales through the atmospheric boiling point and the critical point. These two vapor pressure points and the constants in the equation $\log P^o = a - m/T$ are given in Table 20.1. Adjacent vapor pressure and temperature scales are given for each hydrocarbon on its liquid chart.

Application of Charts. The following step-by-step procedure is followed in applying these charts.

1. From MABP of vapor and system temperatures find Θ^V.

2. From system pressure and Θ^V find $\bar{f}^V/Py$.

3. From MABP of liquid and system temperature find Θ^L.

4. From system pressure and Θ^L find $\bar{f}^L/P^ox$.

5. From system temperature find P^o.

6. From above readings calculate $K = \left[\frac{\bar{f}^L/P^ox}{\bar{f}^V/Py}\right]\left[\frac{P^o}{P}\right]$

7. Find equilibrium vapor and liquid compositions from "K" values.

8. Compute MABP of vapor and liquid and compare with values used in 1 and 3.

Example. The application of these charts will be illustrated by calculation of the "K" values for the three-component mixture solved in Part 19 by the use of the generalized P-T-Θ charts. Following are the experimental data at 160° F and 500 pounds per square inch absolute pressure and the MABP calculations:

Hydrocarbon	OBSERVED DATA			MABP CALCULATIONS*		
	y	x	K = y/x	BP, B° R	yB	yB
Methane	0.661	0.116	5.70	201	132.9	23.3
Propane	0.238	0.259	0.919	416	99.0	107.7
n-Pentane	0.101	0.625	0.162	556.6	56.2	347.9
	1.000	1.000	....	....	288.1°R or −170°F	478.9°R or 19°F

* Boiling points in °F could also be used.

Reading from charts:

	VAPOR PHASE		LIQUID PHASE		Vapor Pressure
	Θ^V	$\bar{f}^V/Py$	Θ^L	$\bar{f}^L/P^ox$	
Methane	2.5	1.000	1.21	0.385	7500
Propane	0.99	0.715	0.90	0.79	390
n-Pentane	0.89	0.535	0.70	1.05	41.5

Calculations:

	$\frac{\bar{f}^L/P^ox}{\bar{f}^V/Py}$	P^o/P	"K" VALUES	
			Calculated	Observed
Methane	0.3815	15.0	5.72	5.70
Propane	1.105	0.78	0.862	0.919
n-Pentane	1.962	0.082	0.163	0.162

Accuracy of Charts. These new P-T-C "K" value charts are in good agreement with similar charts developed recently by DePriester[1] for 12 light hydrocarbons (methane, ethylene, ethane, propylene, propane, isobutylene, isobutane, butane, isopentane, pentane hexane, and heptane) covered by the Kellogg[2] charts.

The charts lose accuracy within 50 psia of the critical pressure of the liquid phase mixture and also for components which are in low concentration in the liquid and the molal average boiling points of the liquid and vapor phases are close to each other. The M. W. Kellogg Company, in the preface to their published "K" charts, recommended against using their charts when the pressure is between 500 and 800 psia and the molar average boiling points of the liquid and vapor phases (b^L and b^V) are within 30° F of one another. The accuracy of the present charts is found to decrease for any component with liquid mole fraction less than 0.3 and $b^L - b^V < 30°$ F.

An evaluation of the new charts for conditions most frequently encountered in hydrocarbon process calculations was made. Tables 20.2 and 20.3 show comparisons of these two PTC K value correlations. The DePriester charts are limited to 1,000 psia.

The distributions of the errors in these new charts for each hydrocarbon are given in Tables 20.4, 20.5, and 20.6 for three pressure ranges, i.e. 0 to 300 psia, 301 to 700 psia and 701 to 3,600 psia. For pressures below 300 psia the new charts read slightly low; while for pressures above 700 psia they give values that are a little high. Below 300 psia the average absolute deviation was 6 percent for 157 points. In the 301 to 700 psia range the average absolute deviation was 5 percent for 98 points. Between 701 and 3,600 psia the absolute average deviation was 8 percent for 75 points.

A requirement of vapor-liquid K charts is that they predict the vapor pressure of the pure component at all temperatures up to the critical point. In other words, the predicted K values from the charts should be unity

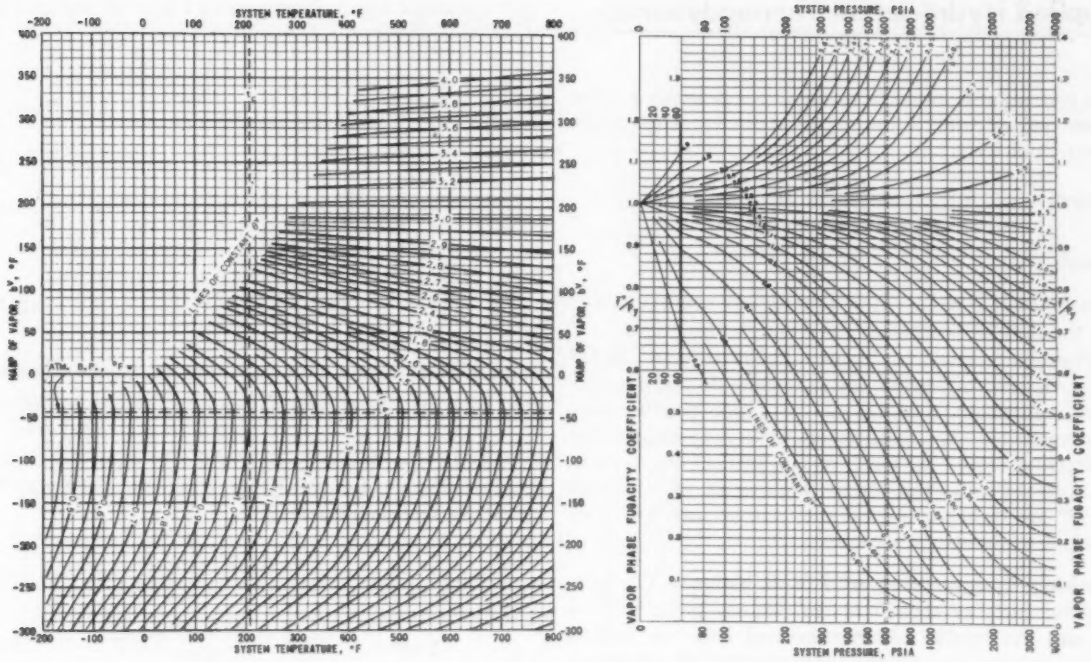

FIGURE 20.10—Propane vapor coefficient for vaporization equilibrium constants. Normal BP, $b_i = -43.7°$ F.

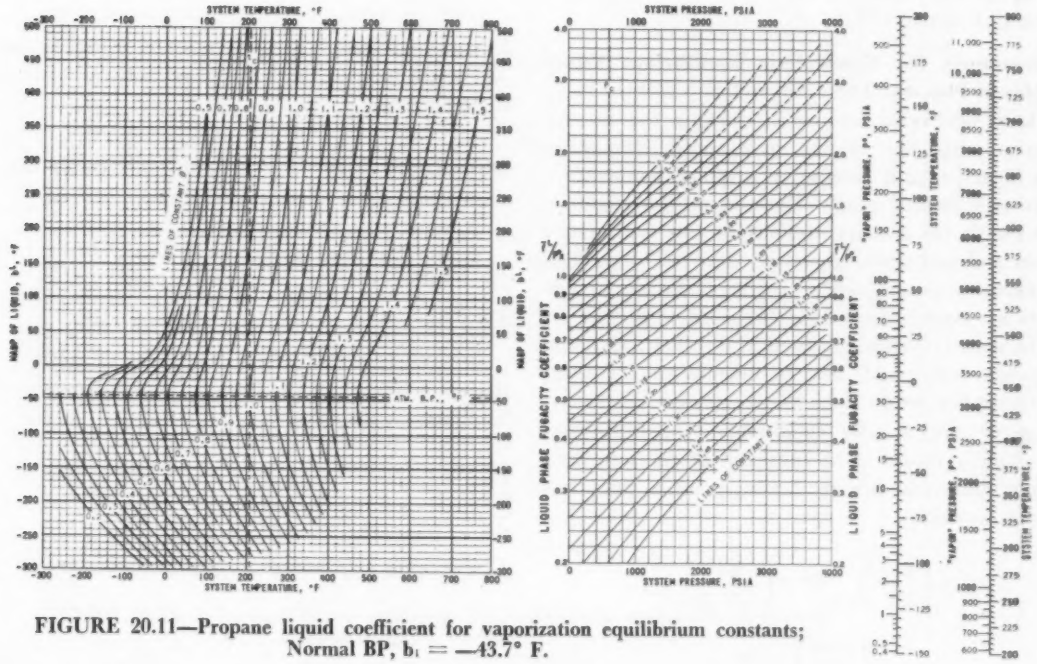

FIGURE 20.11—Propane liquid coefficient for vaporization equilibrium constants; Normal BP, $b_i = -43.7°$ F.

Follow these steps to calculate K's from charts:

1. From MABP of vapor and system temperature find Θ^v.
2. From system pressure and Θ^v find $\bar{f}^v/Py$.
3. From MABP of liquid and system temperature find Θ^L.
4. From system pressure and Θ_L find $\bar{f}^L/P^o x$.
5. From system temperature find P^o.
6. From above readings calculate $K = [(\bar{f}^L/P^o x)/(\bar{f}^v/Py)]\ (P^o/P)$.
7. Find equilibrium vapor and liquid compositions from K values.
8. Compute MABP of vapor and liquid and compare with values used in 1 and 3.

at a system pressure equal to the vapor pressure at some given temperature. In terms of these fugacity coefficients.

when $\bar{f}^L/P^o x = \bar{f}^V/Py$

$T_r = \Theta^V = \Theta^L$

and $P^o = P$

A test of these charts show that this is essentially true for the first 13 components covered in this work.

The charts given in Figures 20.28* through 20.33* for n-Octane, n-Nonane and n-Decane do not pass this pure component K = 1.0 at the vapor pressure test, however. These K values for higher boiling components drift below unity as much as 10 percent for decane. In spite of this, the charts Figures 20.28* through 20.33* are included because they can be used with corrections to the vapor pressure.

Machine Computation of PTC K-Values. The generalized fugacity coefficient correlations given in Part 19 and the specific charts presented here are tedious in application due to the large number of numerical calculations and the successive approximations that are required. A machine program based on the generalizations was developed for the digital computer.[4] This was done by fitting regression equations to the curves of Figures 19.1 through 19.6.

Requirements for Coexisting Equilibrium Vapor and Liquid Phases. The relationships presented below have been developed for use in showing the thermodynamic consistency of the generalized correlations giving fugacities as a function of pressure, temperature, and average boiling point. These equations would be applied with the activity coefficients plus the mixture volumes and enthalpies, separately derived. Using these equations and generalized properties, it should be possible to test experimental data. It should be pointed out that the activity coefficients used in this thermodynamic consistency test would have to include any necessary characterization correction.

Fugacity and activity coefficients of hydrocarbons were recently shown to be functions of pressure, temperature, and molal average boiling point of the phase. For such functions,

$$d\ \ln f = \left(\frac{\partial \ln f}{\partial P}\right)_{T,B} dP + \left(\frac{\partial \ln f}{\partial T}\right)_{P,B} dT + \left(\frac{\partial \ln f}{\partial B}\right)_{P,T} dB \qquad (20.1)$$

and

$$\Sigma\, x d\ln f = \Sigma\, x\left(\frac{\partial \ln f}{\partial P}\right)_{T,B} dP + \Sigma\, x\left(\frac{\partial \ln f}{\partial T}\right)_{P,B} dT + \Sigma\, x\left(\frac{\partial \ln f}{\partial B}\right)_{P,T} dB \qquad (20.2)$$

Three summations in Equation 20.2 may be replaced by their equivalents:

$$\Sigma\, x\left(\frac{\partial \ln f}{\partial P}\right)_{T,B} = \frac{V_m}{RT} \qquad (20.3)$$

$$\Sigma\, x\left(\frac{\partial \ln f}{\partial T}\right)_{P,B} = -\frac{(H - H^o)_m}{RT^2} \qquad (20.4)$$

$$\Sigma\, x\left(\frac{\partial \ln f}{\partial B}\right)_{P,T} = 0 \qquad (20.5)$$

Equations 20.3 and 20.4 are sums of partial volumes and partially enthalpy differences for the components of mixtures, the subscript "m" designating the value of V or ΔH for the mixtures. Equation 20.5 is a form of the Gibbs-Duhem equation. These three equations may be found in thermodynamics texts.

Combining Equations 20.2, 20.3, 20.4, and 20.5 gives

$$\Sigma\, x d\ln f = \frac{V_m}{RT} dP - \frac{(H - H^o)_m}{RT^2} dT \qquad (20.6)$$

Equation 20.6 is equivalent to the more familiar equation

$$\Sigma\, x d\mu = VdP - SdT \qquad (20.7)$$

Equation 20.6 applies to either liquid or vapor phase. It will be the basic for isothermal and isobaric relationships to be derived.

Isothermal Case. At constant temperature the last term in Equation 20.6 is zero, giving

$$\Sigma\, x d\ln f = \frac{V_m}{RT} dP \qquad (20.8)$$

for either phase.

Rewriting for each phase in terms of the activity coefficients $\Phi^V = \bar{f}^V / Py$ and $\Phi^L = \bar{f}^L / P^o x$ and combining to eliminate dP gives

$$\frac{\Sigma\, x(d\ln\Phi^L)}{\Sigma\, y(d\ln\Phi^V + d\ln P)} = \frac{V^L{}_m}{V^V{}_m} \qquad (20.9)$$

Changing to a difference form for small intervals

$$\frac{\Sigma\, y\left(\ln\frac{\Phi_2{}^L}{\Phi_1{}^L}\right)}{\Sigma\, y\left(\ln\frac{\Phi_2{}^V}{\Phi_1{}^V} + \ln\frac{P_2}{P_1}\right)} = \frac{V^L{}_m}{V^V{}_m} \qquad (20.10)$$

Equation 20.10 gives an isothermal relationship between the vapor and liquid activity coefficients of a mixture with coexisting vapor and liquid phases and the volume of each phase. Equation 20.10 is restricted to isothermal

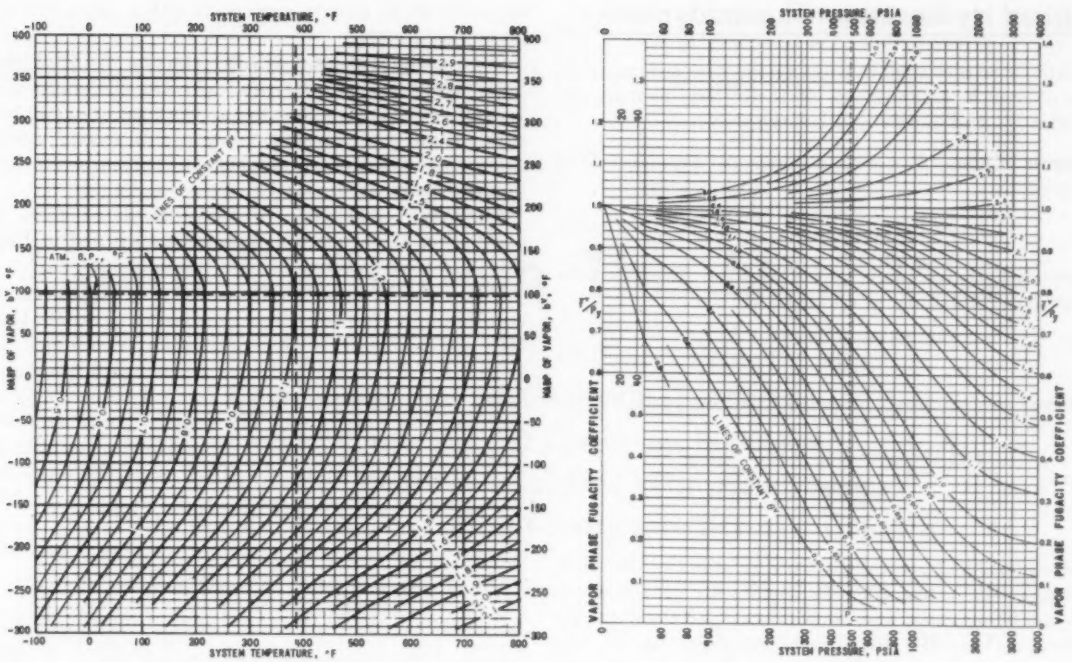

FIGURE 20.22—n-Pentane vapor coefficient for vaporization equilibrium constants. Normal BP, $b_i = 96.9°$ F.

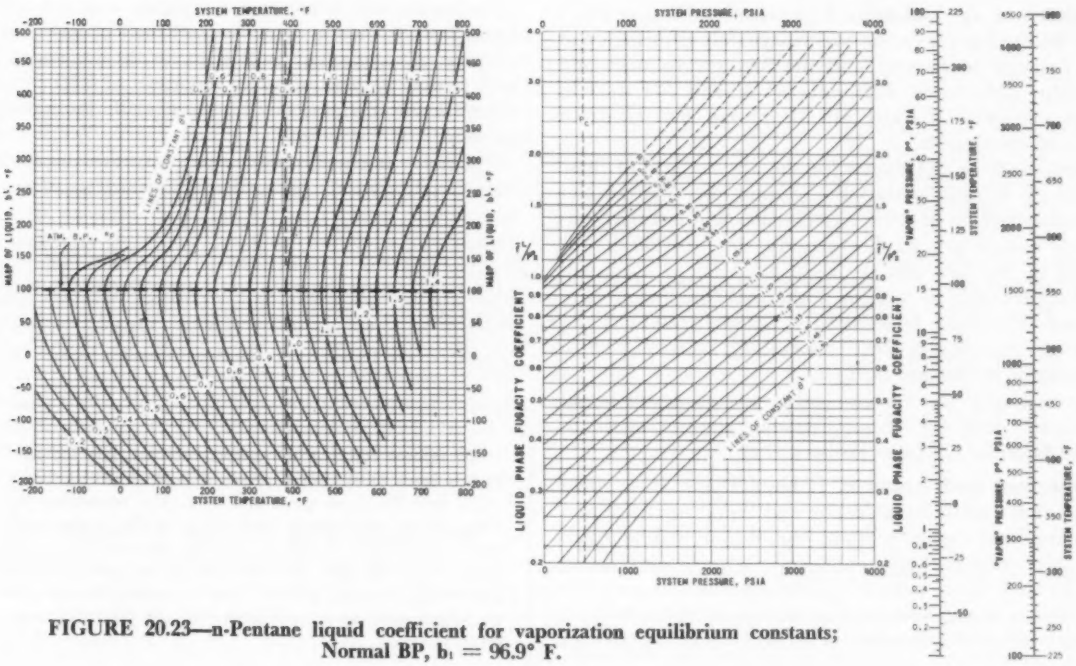

FIGURE 20.23—n-Pentane liquid coefficient for vaporization equilibrium constants; Normal BP, $b_i = 96.9°$ F.

Follow these steps to calculate K's from charts:

1. From MABP of vapor and system temperature find Θ^v.
2. From system pressure and Θ^v find $\bar{f}^v/P_y$.
3. From MABP of liquid and system temperature find Θ^L.
4. From system pressure and Θ_L find $\bar{f}^L/P^o x$.
5. From system temperature find P^o.
6. From above readings calculate $K = [\bar{f}^L/P^o x)/(\bar{f}^v/P_y)]\ (P^o/P)$.
7. Find equilibrium vapor and liquid compositions from K values.
8. Compute MABP of vapor and liquid and compare with values used in 1 and 3.

conditions, so a change in pressure must be accompanied by a change in compositions of each phase to maintain equilibrium and satisfy this relationship.

Isobaric Case. A constant pressure Equation 20.6 becomes

$$\Sigma\, x\, d\ln f = -\frac{\Delta Hm}{RT^2}dT \qquad (20.11)$$

Rewriting for each phase in terms of the activity coefficients and combining to eliminate dT

$$\frac{\Sigma\, y\,(d\ln \Phi^L + d\ln P^o)}{\Sigma\, x\,(d\ln \Phi^V)} = \frac{\Delta H_m{}^L}{\Delta H_m{}^V} \qquad (20.12)$$

changing to a different form for small intervals

$$\frac{\Sigma\, x\left(\ln\frac{\Phi_2{}^L}{\Phi_1{}^L} + \ln\frac{P_2{}^o}{P_1{}^o}\right)}{\Sigma\, y\left(\ln\frac{\Phi_2{}^V}{\Phi_1{}^V}\right)} = \frac{\Delta H_m{}^L}{\Delta H_m{}^V} \qquad (20.13)$$

Equation 20.13 gives an isobaric relationship between the vapor and liquid fugacity coefficients of a mixture with coexisting vapor and liquid phases and the enthalpy difference $(H - H^o)$ for each phase. Equation 20.13 is restricted to isobaric conditions, so a change in temperature must be accompanied by a change in compositions of each phase to maintain equilibrium and satisfy this relationship.

Isothermal vs. Isobaric. Equations 20.9 and 20.13 may be used to check the thermodynamic consistency of the fugacity coefficients and the mixture volumes and enthalpy differences. The value of V and ΔH used in these equations should not be those derived from fugacity coefficients.

Finding V or ΔH values for the applications of these equations is usually out of the question. The simpler equation derived below for isothermal and isobaric conditions cannot prevail. Fortunately, the problem is simplified by the fact that the right hand side of Equation 20.8 is very close to zero for isothermal equilibrium conditions. The right hand side of Equation 20.11 is not close to zero for isobaric conditions, however. These were found by Ibl and Dodge.[5]

Accordingly, the recommended test of vapor-liquid equilibria data for thermodynamic consistency is to apply Equation 20.14 to isothermal data.

Isothermal and Isobaric. If both T and P are held constant for equilibrium vapor and liquid mixtures and a composition change is made, equilibrium will be upset. For this reason isothermal and isobaric conditions should not be used for a test of equilibrium data. In practice it has been found that these conditions can be used with satisfactory results, however, if small composition changes are used.

A constant temperature and pressure, Equation 20.6, becomes

$$\Sigma\, x\, d\ln f = 0 \qquad (20.14)$$

Rewriting for each phase in terms of the fugacity coefficients and combining and changing to a different form for small intervals

$$\Sigma\, x \ln\frac{\phi_2}{\phi_1} = 0 \qquad (20.15)$$

Equation 20.15 may be applied to either vapor or liquid phase, separately.

This calculation is made by starting with an equilibrium vapor (or liquid) and allowing the composition to change slightly so that the mixture moves away from equilibrium. For a vapor mixture this second composition should be in the superheated region, while for a liquid mixture it should be subcooled liquid.

Fugacity coefficients are next calculated from the correlation being tested. These are substituted in Equation 20.15 using average mole fractions.

Following is an example of this calculation on the equilibrium vapor from experimental data at 60° F and 500 psia. Point 1 is the equilibrium condition. The values of y_2 were selected close to but slightly removed from the y_1 values so that $\Sigma\, y_2 = 1$. Point 2 is not necessarily at equilibrium. The fugacity coefficients were estimated from the charts presented in this installment. This was done by using the 60° F and 500 psia conditions with the average boiling points at points 1 and 2.

	COMPOSITION			ACTIVITY COEFFICIENT			
	y_1	y_2	y_{av}	ϕ_1	ϕ_2	ϕ_2/ϕ_1	$y_{av}\ln\phi_2/\phi_1$
Methane	0.661	0.70	0.6805	1.009	0.989	0.9805	—0.01348
Propane	0.238	0.25	0.2440	0.715	0.731	1.0230	+0.00540
Pentane	0.101	0.05	0.0755	0.540	0.570	1.0555	+0.00408
	1.00	1.00	1.0000	.....	.....	.....	—0.004

The summation is not zero, indicating that the effect of composition on the fugacity coefficient of methane is too great. This calculation is sensitive, as evidenced by the fact that a fugacity coefficient ratio of 0.99 instead of 0.9805 for methane would have made the summation zero.

This $\Sigma = 0$ check only proves that the results are consistent. It does not prove that results are accurate.

LITERATURE CITED

[1] DePriester, C. L., "Light Hydrocarbon Vapor-Liquid Distribution Coefficients," Chemical Engineering Progress 49, Symposium Series No. 7, pp. 1 to 43 (1953).
[2] The M. W. Kellogg Company, "Liquid-Vapor Equilibria in Mixtures of Light Hydrocarbons—MWK Equilibrium Constants, PolycoData" (1950).
[3] N.G.S.M.A. Technical Data Book, 1951.
[4] Goodwill, M. J., E-Gordon and J. W. Paylor, "Machine Computations of K-Values," C.E.P. Sym Series No. 21, Vol. pp. 1-7 (1959).
[5] Ibl, N. V. and Dodge, B. F., Chemical Engineering Science, 2, 120 (1953).

All figures referred to in this text are not included in this issue. Only Figures 20.1, 20.2, 20.3, 20.10, 20.11, 20.22 and 20.23 are presented here. The remaining figures will be available in larger size in the forthcoming book by Professor Edmister covering the articles in this series. Look for the announcement in an early issue of PETROLEUM REFINER. These remaining figures give the liquid and vapor coefficients for the following compounds:

20.4, 20.5 Ethylene	**20.20, 20.21 i-pentane**
20.6, 20.7 Ethane	**20.24, 20.25 n-hexane**
20.8, 20.9 Propylene	**20.26, 20-27 n-Heptane**
20.12, 20.13 i-Butane	**20.28, 20.29 n-Octane**
20.14, 20.15 i-Butylene	**20.30, 20.31 n-Nonane**
20.16, 20.17 l-Butylene	**20.32, 20.33 n-Decane**
20.18, 20.19 n-Butane	

TO BE CONTINUED

Figure Distillation This New Way

Part 1—New Convergence Method Will Handle Many Cases
Part 2—Product Purity Can Set Conditions for Column
Part 3—Consider Multi-Feed Columns With Side-Streams
Part 4—Explore Operating Characteristics of a Column

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ONLY ONE POINT of operation for a distillation column with a fixed number of plates and a given reflux rate is suitable to yield the maximum concentration of a given component in the distillate or the bottoms product. This is demonstrated by exploring a wide range of operating conditions for distillation column.

The newly disclosed convergence method[17] is used to solve a typical problem on a digital computer. Equations are proposed to represent total reflux in the rectifying section and total reboil in the stripping section. Then the compositions of the distillate and the bottoms are examined between these two limits to find the optimum operation. The method is expanded also to include side streams.

The results of the example problems are shown in Figure 11. Notice the maximum concentration of i-C_4 is achieved at a lower distillate rate than that for n-C_4. A detailed discussion of the example problem will be given after setting up the basic equations.

CONVERGENCE METHOD SETS EQUATIONS

Total Reflux in the Rectifying Section. The condition of total reflux in the rectifying section arises when the specifications, $D = 0$ and L_o = finite number, are made. For this case $B = F$, $V_j = L_{j-1}$ (where $1 \leqq j \leqq f-1$), $\overline{V}_f = L_{f-1}$. Also material balances show $y_{ji} = x_{j-1,i}$ (where $1 \leqq j \leqq f-1$). A combination of this relationship with the equilibrium relationship, $y = Kx$, gives the following equations for the rectifying section.

$$\frac{y_{1i}}{x_{oi}} = 1$$

$$\frac{x_{1i}}{x_{oi}} = \frac{1}{K_{1i}}$$

$$\frac{x_{2i}}{x_{oi}} = \frac{1}{K_{2i}\,K_{1i}}$$

$$\vdots$$

$$\frac{x_{ji}}{x_{oi}} = \frac{1}{K_{ji}\,K_{j-1,i}\cdots K_{2i}\,K_{1i}}, \text{ where } j \leqq f-1 \qquad (75a)$$

Since $\bar{y}_{fi} = x_{f-1,i}$,

$$\frac{\bar{y}_{fi}}{x_{oi}} = \frac{1}{K_{f-1,i}\,K_{f-2,i}\cdots K_{2i}\,K_{1i}} \qquad (75b)$$

The match at the feed plate for the case of total reflux in the rectifying section may be effected in the following manner.

By the conventional stripping section equations, stated in Part 1, the quantity $(v_{fi}/b_i)_{ca}$ is computed. Multiplication of both sides of Equation (75b) by $\overline{V}_f/L_o$ yields $(\bar{v}_{fi}/l_{oi})_{ca}$. Since $\bar{v}_{fi} = v_{fi} + v_{Fi}$, the general matching equation for a feed of any thermal condition is given by

$$\left(\frac{l_{oi}}{b_i}\right)_{ca} = \frac{\left(\frac{v_{fi}}{b_i}\right)_{ca} + \frac{v_{Fi}}{FX_{Fi}}}{\left(\frac{\bar{v}_{fi}}{l_{oi}}\right)_{ca}} \qquad (76)$$

This series discusses a new convergence method which makes the digital computer a powerful tool for handling multicomponent distillation problems. To keep up with these developments, you may want to go back and review these earlier parts:

- **Part 1—New Convergence Method Will Handle Many Cases, PETROLEUM REFINER, June 1959, p221.**
- **Part 2—Product Purity Can Set Conditions for Column, PETROLEUM REFINER, July 1959, p151.**
- **Part 3—Consider Multi-Feed Columns with Side-Streams, PETROLEUM REFINER, October 1959, p139.**

Since D = 0 and B = F, the corrected b_i's are given by

$$(b_i)_{co} = FX_{Fi} \quad (77)$$

and the corrected values of the l_{oi}'s are given by

$$(l_{oi})_{co} = \Theta_o\,(l_{oi}/b_i)_{ca}\,(b_i)_{co} \quad (78)$$

Summing both sides of Equation (78) over all components yields

$$L_o = \sum_{i=1}^{c} \Theta_o\,(l_{oi}/b_i)_{ca}\,(b_i)_{co} \quad (79)$$

which may be used for the calculation of Θ_o. However, as is evident from the equations which follow, it is not necessary to evaluate Θ_o. The corrected compositions to be employed for the bubble point calculations are obtained by use of the following equations.

$$x_{ji} = \frac{(x_{ji}/x_{oi})_{ca}\,(x_{oi})_{co}}{\sum_{i=1}^{c} (x_{ji}/x_{oi})_{ca}\,(x_{oi})_{co}}, \text{ where } 1 \leqq j \leqq f-1 \quad (80)$$

and

$$x_{ji} = \frac{(l_{ji}/b_i)_{ca}\,(b_i)_{co}}{\sum_{i=1}^{c} (l_{ji}/b_i)_{ca}\,(b_i)_{co}}, \text{ where } f \leqq j \leqq N+1 \quad (81)$$

The calculated values appearing in Equations (80) and (81) are computed on the basis of assumed temperature and L/V profiles. Equation (75) is used for the rectifying section and the appropriate equations of Part 1 are used for the stripping section. The corrected values of the b's are given by Equation (77). The expression for the calculation of the corrected values of the x_o's is obtained by division of each member of Equation (78) by the corresponding member of Equation (79) to give

$$(x_{oi})_{co} = \frac{(l_{oi}/b_i)_{ca}\,(b_i)_{co}}{\sum_{i=1}^{c} (l_{oi}/b_i)_{ca}\,(b_i)_{co}} \quad (82)$$

With partial condensers, the composition of the distillate (vapor) is also of interest at D = 0. It is computed as follows:

After the temperature T_o has been obtained by the calculation of the bubble point of the corrected x_{oi}'s, the desired composition is given by the relationship, $X_{Di} = y_{oi} = K_{oi}\,(x_{oi})_{co}$.

The total molal flow rates in the stripping section are calculated by use of conventional material and enthalpy balances. The condenser duty is calculated by use of enthalpy and material balances written around the condenser. Then the reboiler duty is given by overall enthalpy and material balances.

The above calculational procedure for the rectifying section is of the general type proposed by Thiele and Geddes;[18] whereas, the one given in Part 2 follows the method of Lewis and Matheson.[9]

Total Reboil in the Stripping Section. When a finite value for L_o is specified and D is taken equal to F, the condition of total reboil in the stripping section is realized. The following equations for the stripping section are developed in a manner similar to that described for the case of total reflux in the rectifying section.

$$\frac{x_{N1}}{y_{N+1,1}} = 1$$

$$\frac{x_{N-1,1}}{y_{N+1,1}} = K_{N1}$$

$$\frac{x_{N-2,1}}{y_{N+1,1}} = K_{N-1,1}\,K_{N1}$$

$$\vdots$$

$$\frac{x_{j1}}{y_{N+1,1}} = K_{j+1,1}\,K_{j+2,1}\cdots K_{N-1,1}\,K_{N1}, \text{ where } j>f \quad (83a)$$

and

$$\frac{\bar{x}_{f-1,1}}{y_{N+1,1}} = K_{f1}\,K_{f+1,1}\cdots K_{N-1,1}\,K_{N1} \quad (83b)$$

For the case of total reboil in the stripping section, positive compositions are assured by use of the relationship for the liquid flow rates at the feed plate, $\bar{l}_{f-1,1} = l_{f-1,1} + l_{F1}$. The appropriate equations for the rectifying section (see Part 1) may be employed to give $(l_{f-1,1}/d_i)_{ca}$ and multiplication of both sides of Equation (83b) by $\bar{L}_{f-1}/V_{N+1}$ yields $(\bar{l}_{f-1,1}/v_{N+1,1})_{ca}$. It follows that for a feed of any given thermal condition

$$\left(\frac{v_{N+1,1}}{d_i}\right)_{ca} = \frac{(l_{f-1,1}/d_i)_{ca} + l_{Fi}/FX_{Fi}}{(\bar{l}_{f-1,1}/v_{N+1,1})_{ca}} \quad (84)$$

The development of the following equations is analogous to that given for Equations (77) through (82).

$$(d_i)_{co} = FX_{Fi} \quad (85)$$

$$(v_{N+1,1})_{co} = \Theta_o\,(v_{N+1,1}/d_i)_{ca}\,(d_i)_{co} \quad (86)$$

$$V_{N+1} \sum_{i=1}^{c} \Theta_o (v_{N+1,1}/d_i)_{ca}\,(d_i)_{co} \quad (87)$$

$$(y_{N+1,1})_{co} = \frac{(v_{N+1,1}/d_i)_{ca}\,(d_i)_{co}}{\sum_{i=1}^{c} (v_{N+1,1}/d_i)_{ca}\,(d_i)_{co}} \quad (88)$$

$$x_{ji} = \frac{(l_{ji}/d_i)_{ca}\,(d_i)_{co}}{\sum_{i=1}^{c} (l_{ji}/d_i)_{ca}\,(d_i)_{co}}, \text{ where } 0 \leqq j \leqq f-1 \quad (89)$$

$$x_{ji} = \frac{(x_{ji}/y_{N+1,1})_{ca}\,(y_{N+1,1})_{co}}{\sum_{i=1}^{c} (x_{ji}/y_{N+1,1})_{ca}\,(y_{N+1,1})_{co}}, \text{ where } f \leqq j \leqq N+1 \quad (90)$$

The total liquid and vapor rates in the rectifying section are calculated by use of the appropriate enthalpy and material balances stated in Part 1. As in the previous case, it is not necessary to evaluate either $(v_{N+1,1})_{co}$ or Θ_o. However, the flow rate V_{N+1} is needed in the computation of $(\bar{l}_{f-1,1}/v_{N+1,1})_{ca}$ as described previously. V_{N+1} is obtained as follows: (1) an enthalpy and material balance around the condenser gives the condenser duty, Q_c, (2) an enthalpy and material balance around the entire column yields Q_R and (3) an enthalpy balance around the reboiler gives V_{N+1}.

It should also be pointed out that the temperature of the reboiler may be calculated by either one of two ways. A dew point calculation may be carried out on the basis of the y_{N+1}'s as given by Equation (88) or a bubble point calculation may be made on the basis of the x_{N+1}'s as computed by use of Equation (90). When the desired solution to the problem is obtained, the temperatures so obtained are equal.

Total Recycle (Both Total Reflux and Total Reboil). The condition of total recycle is said to exist throughout a distillation column when

$$\lim_{L_j \to \infty} \frac{V_j}{L_j} = 1 \tag{91}$$

In the following it is supposed that some finite number greater than zero (and less than F) is specified for D (or B) and that throughout the column the limiting condition of total recycle, $V_j/L_j = 1$, prevails. Notice that F, D and B are finite so that

$$F = D + B \tag{92}$$

and

$$FX_{Fi} = d_i + b_i \tag{93}$$

However, since the vapor and liquid flow rates throughout the column are so large, the following results are obtained

$$\bar{v}_{fi} = v_{fi} + v_{Fi} = v_{fi} \tag{94}$$

and

$$\bar{l}_{f-1,i} = l_{f-1,i} + l_{Fi} = l_{f-1,i} \tag{95}$$

In a manner similar to that shown previously, the following expressions are obtained for the rectifying and stripping sections.

$$\frac{x_{1i}}{X_{Di}} = \frac{1}{K_{1i} K_{oi}}, \text{ (for a total condenser } K_{oi} = 1)$$

$$\frac{x_{2i}}{X_{Di}} = \frac{1}{K_{2i} K_{1i} K_{oi}}$$

$$\vdots$$

$$\frac{x_{ji}}{X_{Di}} = \frac{1}{K_{ji} K_{j-1,i} \cdots K_{1i} K_{oi}}, \text{ where } 0 \leqq j \leqq N+1 \tag{96a}$$

and

$$\frac{x_{N+1,i}}{X_{Di}} = \frac{x_{Bi}}{X_{Di}} = \frac{1}{K_{N+1,i} K_{N,i} \cdots K_{1i} K_{oi}} \tag{96b}$$

After $(x_{Bi}/X_{Di})_{ca}$ has been computed by Equation (96b) on the basis of an assumed temperature profile, the value of $(b_i/d_i)_{ca}$ is calculated as follows:

$$\left(\frac{b_i}{d_i}\right)_{ca} = \left(\frac{B}{D}\right)\left(\frac{x_{Bi}}{X_{Di}}\right)_{ca} \tag{97}$$

Then, as shown in Part 1, the corrected value of d_i is given by

$$(d_i)_{co} = \frac{FX_{Fi}}{1 + \Theta_o (b_i/d_i)_{ca}} \tag{98}$$

where Θ_o is the positive root of $g_o(\Theta_o)$, which is defined by,

$$g_o(\Theta_o) = \sum_{i=1}^{c} \frac{FX_{Fi}}{1 + \Theta_o (b_i/d_i)_{ca}} - D \tag{99}$$

The corrected compositions are calculated in the following manner.

$$x_{ji} = \frac{(x_{ji}/X_{Di})_{ca} (X_{Di})_{co}}{\sum_{i=1}^{c} (x_{ji}/X_{Di})_{ca} (X_{Di})_{co}}, \text{ where } 0 \leqq j \leqq N+1 \tag{100}$$

where,

$$(X_{Di})_{co} = \frac{(d_i)_{co}}{D} \tag{101}$$

Special Cases For Columns with Side-Streams. The calculational procedures and convergence methods are readily extended to include more complex columns as follows.

- **Side-Stream W_i Withdrawn from the Rectifying Section. Specifications: L_o is finite, $D = 0$, $W_i = 0$ and $B = F$.**

The treatment for this case is the same as that given previously for "Total Reflux in the Rectifying Section." When W_i is withdrawn as a liquid from some plate of the rectifying section, say plate p, the composition of W_i is the same as that of the liquid leaving plate p. Thus, the composition of W_i is given by Equation (75a) when $j = p$. If W_i is withdrawn as a vapor from plate p, the compositions are given by $y_{pi} = K_{pi} x_{pi}$.

- **Side-Stream W_i Withdrawn from the Rectifying Section. Specifications: L_o is finite, $D = 0$, $0 < W_i < F$**

In order to illustrate this case, suppose the side-stream W_i is withdrawn from plate p of the rectifying section. Calculations from the top of the column down to plate p are carried out as indicated by Equation (75a). After x_{pi}/x_{oi} has been computed, the following molal ratio may be obtained.

$$\frac{w_{1i}}{l_{oi}} = \left(\frac{W_i}{L_o}\right)\left(\frac{x_{pi}}{x_{oi}}\right) \tag{102}$$

Also, from a material balance $y_{p+1,i} = x_{pi}$ and

$$\frac{v_{p+1,i}}{l_{oi}} = \left(\frac{V_{p+1}}{L_o}\right)\left(\frac{x_{pi}}{x_{oi}}\right) \tag{103}$$

where V_{p+1} is the vapor rate assumed for plate $p+1$. After these ratios have been computed, calculations may be continued to the feed plate as indicated by the following equations.

$$\frac{v_{p+2,i}}{l_{oi}} = A_{p+1,i}\left(\frac{v_{p+1,i}}{l_{oi}}\right) + \frac{w_{1i}}{l_{oi}} \tag{104}$$

$$\vdots$$

$$\frac{\bar{v}_{fi}}{l_{oi}} = A_{f-1,i}\left(\frac{v_{f-1,i}}{l_{oi}}\right) + \frac{w_{1i}}{l_{oi}} \tag{105}$$

For the stripping section, the calculations are carried out as indicated in Part 1 for conventional columns. The results for the two sections may be combined to

give a value for b_i/w_{1i} as shown later in Equation (110). However, instead of the usual Equation (77), an over-all material balance gives

$$FX_{Fi} = (w_{1i})_{co} + (b_i)_{co} \quad (106)$$

which leads to

$$(w_{1i})_{co} = \frac{FX_{Fi}}{1 + \Theta_1 (b_i/w_{1i})_{ca}} \quad (107)$$

where,

$$\left(\frac{b_i}{w_{1i}}\right)_{co} = \Theta_1 \left(\frac{b_i}{w_{1i}}\right)_{ca} \quad (108)$$

The quantity Θ_1 is the positive root of $g_1(\Theta_1)$, where

$$g_1(\Theta_1) = \sum_{i=1}^{c} \frac{FX_{Fi}}{1 + \Theta_1 (b_i/w_{1i})_{ca}} - W_1 \quad (109)$$

The calculated value of b_i/w_{1i} is readily obtained by use of the following matching equation which applies (see Table 1 of Part 1) for a feed of any given thermal condition

$$\frac{b_i}{w_{1i}} = \frac{\frac{l_{f-1,i}}{w_{1i}} + \frac{l_{Fi}}{FX_{Fi}}}{\frac{v_{fi}}{b_i} + \frac{v_{Fi}}{FX_{Fi}}} \quad (110)$$

After $l_{f-1,i}/l_{oi}$ has been computed by use of the rectifying section equations, the quantity $l_{f-1,i}/w_{1i}$ follows by division of l_{f-1i}/l_{oi} by w_{1i}/l_{oi}. Once Θ_1 has been determined, the quantity of Θ_o is given directly by Equation (79). The remainder of the calculations are carried out in a manner similar to that described previously.

- **Side-Stream W_1 Withdrawn from the Stripping Section. Specifications: L_o is finite, $D = 0$, $0 < W_1 < F$**

Calculations for the rectifying section are carried out as described under "Total Reflux in the Rectifying Section." The material balances for the stripping section are readily modified as described in Part 3 to account for the side-stream W_1. The equations for the convergence method are the same as those given for the side stream ($W_1 > 0$) in the rectifying section.

- **Total Reflux and Total Reboil with Side-Streams W_1 and W_2 Withdrawn from the Rectifying and Stripping Sections, Respectively.**

For this case, the material balances are represented by Equations (96a) and (96b). Also, the calculated value of b_i/d_i is computed by Equation (97). Similarly,

$$(w_{1i}/d_i)_{ca} = (W_1/D)\ (x_{pi}/X_{Di})_{ca} \quad (111)$$

$$(w_{2i}/d_i)_{ca} = (W_2/D)\ (x_{qi}/X_{Di})_{ca} \quad (112)$$

where the side-streams W_1 and W_2 are withdrawn as liquids from plates p and q of the rectifying and stripping sections, respectively. The equations representing the convergence method contain three Θ's. These equations are identical with those given previously in Part 3.

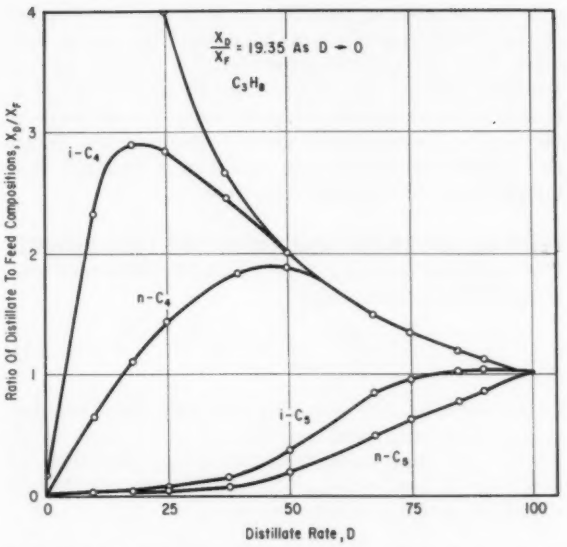

FIGURE 11—At a fixed reflux rate ($L_o = 125$), the composition of the distillate changes with changes in distillate rate.

Also, the Θ's may be computed by a procedure shown in Part 3. The remainder of the calculations are carried out in the usual manner.

ILLUSTRATIVE EXAMPLES

In the development, the equations were in general stated in terms of liquid mole fractions and liquid molal flow rates. If it is desired to make dew point rather than bubble point calculations, the corresponding vapor quantities are obtained by use of $y_{ji} = K_{ji}x_{ji}$, $v_{ji} = S_{ji}l_{ji}$ and $l_{ji} = A_{ji}v_{ji}$.

The example shown in Table 21 was used to illustrate some of the operational characteristics of a column. The results obtained for total reflux in the rectifying section are given in Tables 22 through 24. Table 24 was included in order to illustrate the fact that although $V_j = L_{j-1}$ in the rectifying section (for $D = 0$), V_j is not necessarily equal to V_{j+1}. The equilibrium and enthalpy data used to solve all examples are given in Table 11 of Part 2.

In Figure 11, the operational characteristics of a column at a fixed reflux rate, L_o, and at various distillate rates are shown. The range of operation extends from total reflux in the rectifying section ($D = 0$) to total reboil in the stripping section ($B = 0$). It is to be noted that at $D = 0$, the lightest component of the feed has its maximum mole fraction. As D is increased, the mole fraction of each of the other components except the heaviest of the feed passes through a maxi-

Table 21—Feed Composition and Common Specifications for The Examples

Composition	FX_F	
C_3H_8	5.0	**Specifications:** Boiling point liquid feed, partial condenser, column pressure = 300 psia., three rectifying plates and eight stripping plates plus a reboiler.
i-C_4	15.0	
n-C_4	25.0	
i-C_5	20.0	
n-C_5	35.0	
	100.0	

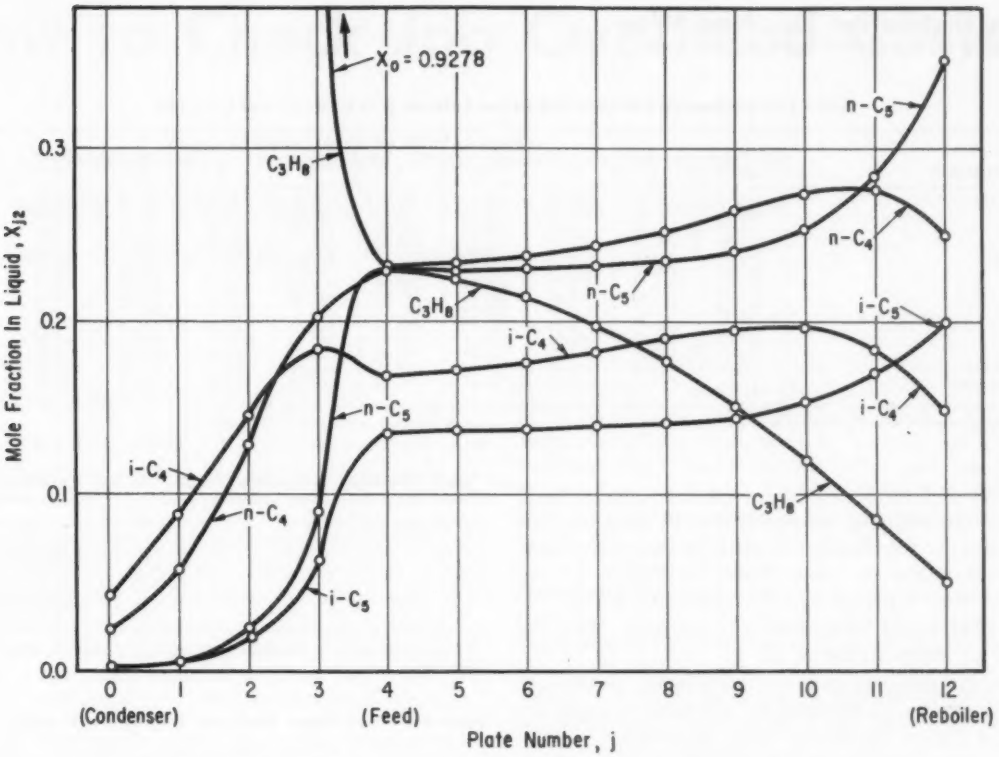

FIGURE 12—These are the final liquid compositions on each plate at total reflux.

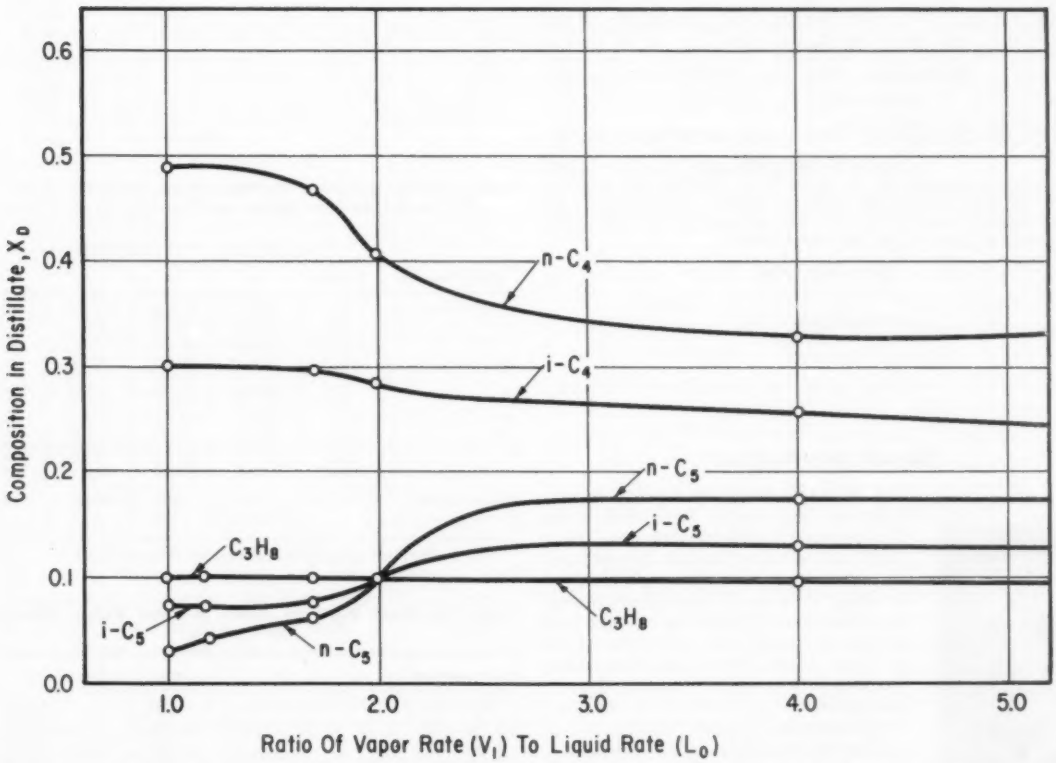

FIGURE 13—At a fixed distillate rate (D = 50), changes in the ratio of vapor overhead to liquid refluxed cause these changes in distillate composition.

Table 22—Temperature Profiles and Reflux Rates at D = O, B = F and L_o = 125.

PLATE NUMBER	TEMPERATURE AT TRIAL NUMBER GIVEN, °F									
	Initial	1	2*	3	4	5	6	7	8	9
0 (Distillate)	140.00	138.29	138.32	138.89	139.82	140.22	140.33	140.34	140.34	140.34
1	150.76	141.80	141.93	143.27	145.34	146.21	146.45	146.47	146.46	146.45
2	161.52	150.00	150.52	153.54	157.83	159.56	160.00	160.01	159.97	159.95
3	172.29	169.38	170.59	176.29	183.50	186.14	186.64	186.56	186.44	186.40
4 (Feed)	183.05	209.53	209.53	216.15	223.92	226.31	226.47	226.16	225.95	225.88
5	193.81	209.12	210.32	216.84	224.36	227.00	227.44	227.28	227.10	227.02
6	204.57	211.13	212.71	218.67	225.59	228.23	228.86	228.83	228.71	228.63
7	215.33	215.40	216.81	221.85	227.83	230.25	230.94	231.01	230.94	230.88
8	226.09	221.67	222.64	226.54	231.32	233.31	233.95	234.07	234.04	234.00
9	236.86	229.69	230.16	232.86	236.30	237.74	238.23	238.36	238.36	238.34
10	247.62	239.47	239.58	241.17	243.21	244.10	244.41	244.51	244.54	244.54
11	258.38	251.87	251.87	252.54	253.13	253.51	253.73	253.85	253.91	253.94
12 (Reboiler)	269.14	269.14	269.14	269.14	269.14	269.14	269.14	269.14	269.14	269.14
L_o (Calculated)	.....	114.72	118.41	87.47	81.28	107.12	121.46	125.78	125.96	125.39

* All profiles other than the one for trial No. 1 are averaged. Vapor rates assumed constant at 125 for the first two trials.

mum. When D is increased to the condition of total reboil in the stripping section (D = F, B = 0), the composition of the distillate is equal to that of the feed. Analogous results to those shown in Figure 11 are obtained when a plot of x_{Bi}/X_{Fi} versus B is made.

The final liquid compositions on each plate (at D = 0) are shown in Figure 12.

When the distillate rate is fixed and the reflux rate is varied, the results obtained for the same example are shown in Figure 13. When V_1/L_o approaches 1, total recycle throughout the entire column is approached. The solution of this example by the proposed method of convergence is given in Tables 25 and 26. The range of operation displayed in Figure 13 extends from total recycle, $V_1/L_o = 1$, to the limiting condition of no liquid reflux for the rectifying section, $L_o = 0$. In the limit as L_o approaches zero, X_{Di} approaches $\bar{y}_{fi}$, the mole fraction of component i in the vapor entering the plate above the feed plate.

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SYMBOLS USED

(See Parts 1 and 3)

LITERATURE CITED

(See Parts 1 and 3)

Table 23—Final Composition for D = O, B = F and L_o = 125.

Component	X_F	X_D*
C_3H_8	0.05	0.96757089
i-C_4	0.15	0.23468365 x 10^{-1}
n-C_4	0.25	0.87593467 x 10^{-2}
i-C_5	0.20	0.13173418 x 10^{-3}
n-C_5	0.35	0.83762787 x 10^{-4}

* Used to denote mole fraction of the vapor in equilibrium with the liquid stream L_o.

Table 24—Final Vapor Rates for D = O, B = F and L_o = 125.

Plate Number	Vapor Rate
1	125.00
2	119.10
3	109.07
4 (Feed)	97.47
5	86.98
6	87.42
7	88.03
8	88.87
9	90.00
10	91.41
11	92.88
12 (Reboiler)	94.06

Table 25—Temperature Profiles, Total Distillate Rates and . . . Values of Θ at Total Reflux and Total Reboil, D = B = 50.

Plate Number	Temperature, °F at Trial Number Given				
	Initial	1	2*	3	4
0 (Distillate)	140	224.60	224.84	224.83	224.83
1	150	265.33	255.55	255.69	255.76
2	160	286.98	271.43	271.87	272.08
3	170	304.26	286.82	287.52	287.85
4 (Feed)	180	315.21	300.11	300.87	301.23
5	190	321.38	310.36	311.00	311.30
6	200	324.84	317.61	318.07	318.28
7	210	326.94	322.48	322.78	322.92
8	220	328.37	325.70	325.89	325.97
9	230	329.46	327.86	327.98	328.03
10	240	330.38	329.38	329.45	329.48
11	250	331.18	330.51	330.55	330.56
12 (Reboiler)	260	331.90	331.39	331.42	331.43
D (Calculated)	...	7.16	52.37	50.68	50.00
Θ	...	3.92 x 10^{-6}	1.57	1.16	1.001

* All profiles other than the one for trial No. 1 are averaged.

Table 26—Final Distillate Rates at Total Reflux Throughout The Column.

Composition	FX_F	
C_3H_8	5.0	4.9999
i-C_4	15.0	14.9921
n-C_4	25.0	24.8659
i-C_5	20.0	3.7926
n-C_5	35.0	1.3494
	100.0	49.9999

About the Author

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J. A. McDonough is a graduate student at Texas A&M. He attended the University of Cincinnati and Texas A&M and received his B.S. degree from the latter institution in 1956. After working in research and development for Procter & Gamble for a year and a half, he returned to graduate school at Texas A&M. He is presently working towards a Doctor of Philosophy degree, having completed his M.S. in chemical engineering in January 1960.

(For biographies of W. N. Lyster, S. L. Sullivan, Jr., and C. D. Holland, see PETROLEUM REFINER, *July 1959, Page 156.)*

How to Check Job Overhead Costs

Overheads are a true cost of doing business and should be included in all estimates. Use this check list to make sure none of these items are overlooked

John Mylo
The Chemstrand Corporation, Pensacola, Fla.

PERCENTAGE APPLICATION of overhead costs is fine for talking purposes but presents many profit pitfalls when applied to a final job estimate. When estimates are made for appropriation or lump sum bids, an item-by-item study should be made for the overhead account.

The dictionary defines overhead as those general charges collected in any business which cannot be charged directly to any part of the work or product—rent, taxes, insurance, lighting, heating, accounting, depreciation and other items. These items can account for as much as 20 percent of the total estimated direct cost of a project.

Days and weeks are often spent in the preparation of an estimate with much emphasis being given to the smallest of details. But, with the direct cost established, an allowance of 5, 10 or 15 percent is most often tacked on for job overheads.

In the case of a contractor bidding on work, this item will have a marked effect on his profit. If the overhead item is too low, small will be the profit, if any. By the same token, if the estimated overhead is high, work can be a long time in coming.

Overheads, the cost of doing business as it affects construction, are complex, with many factors entering into the picture. However, this review will cover job overhead with only passing comments on the other indirect charges. Excluded from this review will be the fixed or general expense that must be paid regardless of the amount of work done. This expense is a budgeted annual figure and usually prorated based on the total volume of work. This overhead item is also a cost of doing business, but some tend to overlook it.

Contingency and Profit. Though not a true overhead item, contingency and profit should be noted to complete the indirect cost category, since their effect plays an important part in doing business. Contingency, as employed in the contracting business, is that cost included as an indirect charge for the unknown. Such items as delays, caused by weather, material and equipment delivery and strikes, along with minor omissions in the estimate, are the prime factors which make up the contingency category. There are no set rules which govern this account and it is the estimator's responsibility to analyze these conditions, since they have a pronounced effect on each project.

Since profit is the cost for doing business, the above mentioned overhead items have a marked effect on profit. If these items are omitted and must be absorbed by the profit, little or no profit will be realized. Profit in itself is based on what the contractor thinks the market will bear; but, with a "guess-timate" for the overhead items, profits for the effort and risk may be too small or none at all. Overheads are a true cost, the cost of doing business and should be included in all estimates.

Overhead Account. Items which make up the job overhead account and what these items encompass are outlined here. No method for determining the worth of each item will be given since, here again, it's the responsibility of the estimator to analyze each item based on information and conditions as it may affect the project. To supply methods or percentage factors for determining the worth of each item would only tend to confuse this already complex problem.

Some of the items may not be applicable for each project, but those which do apply should be given the same careful consideration that was given in determining the installed cost for that yard of concrete or ton of steel.

CONSTRUCTION AND JOB OVERHEAD ACCOUNT

Item No. 0.100 General Expense

0.101 **Salaries**—Project manager, superintendent, general foreman, engineers, purchasing agents, accountants and other office and field personnel whose salaries cannot be distributed to direct cost items.

0.102 **Wages**—Office, clerical, field, truck drivers, labor and warehouse personnel whose wages cannot be distributed to direct cost items.

0.103 **Insurance and Taxes on Labor**—FICA (Social Security) state and federal unemployment, employers liability and workmen's compensation insurance. (This account should be analyzed closely, since states differ in their laws and rates. Sliding scales are also employed on Workmen's Compensation Insurance in some states and based on employer's merits.)

0.104 **Job Office Expense and Supplies**—All expense and supplies incurred in the operation of an office which includes such items as postage, telephone, and telegraph, paper, forms and office equipment.

0.105 **Outside Engineering Expense**—Such expense items as may be incurred for surveying, soil and material testing and inspecting service, as may be required.

0.106 **Home Office Expense**—Such expense as may

be incurred from operations performed by the home office. Excludes all fixed or general expense.

0.107 **Safety, Security and Medical**—All such expense items as safety hats, goggles, fire protection equipment, rain coats, identification badges, first aid equipment and supplies; also included is the service of doctors, nurses, watchmen and guards for which a contract or purchase order is issued.

0.108 **Travel Expense**—Such expense as may be incurred by contractor's personnel on business for the project.

0.109 **Photographs**—Such expense as may be incurred for progress reports or that may be requested from time to time by the owner.

0.110 **Warehouse Expense**—Such expense as may be incurred in receiving and warehouse operations as well as cost resulting from ground rental or warehouse leases.

0.111 **Certification of Welders**—Such expense as may be incurred for welders examination.

0.112 **Interest on Borrowed Capital**—Such expense as may be incurred by the contractor for use of his money for the benefit of an owner.

Item No. 0.200 Insurance and Contingencies—Such expense as may be incurred for the protection of the owner. (All such insurance, bonds and contingent policies should be listed as required—201—fire insurance, 202—performance bond, 203—owners' contingent policy, etc.)

Item No. 0.300 Taxes

0.301 **Licenses and Permits**—Such expense as may be incurred, stipulated by law in the area where the facility is to be installed.

0.302 **Sales and Use on Equipment**—Such expense as may be incurred, stipulated by law in the area where the facility is to be installed.

0.303 **Sales and Use Tax on Material and Supplies**—Such expense as may be incurred, stipulated by law in the area where the facility is to be installed.

0.304 **Property**—Such expense as may be incurred, stipulated by law in the area where the facility is to be installed.

About the Author

John Mylo

John Mylo was chief estimator for The Chemstrand Corp. at Pensacola, Fla., when this article was prepared. He was responsible for the preparation of all types of cost estimates. He is presently an estimater and project manager for G. C. Colyer Co., Anniston, Ala. Mylo has 14 years of experience in construction as estimater, cost engineer, superintendent, and project engineer with several engineer-constructor companies. He attended Purdue University and is a charter member of the American Association of Cost Engineers.

Item No. 0.400 Temporary Facilities and Maintenance

0.401 **Temporary Construction**—Such expense as may be incurred for temporary construction and removal of these facilities at the completion of the project.

0.402 **Temporary Maintenance**—Such expense as may be incurred to maintain these facilities for the duration of the project.

0.403 **Instruction to Owner Personnel**—Such expense as may be incurred for instructing owner personnel in the operation and maintenance of this facility. Also included is the expense involved in start up for stand-by personnel.

Item No. 0.500 Indirect Construction and Expense

0.501 **Non-Expendable Construction Tools and equipment**—Such expense as may be incurred for tools and equipment, accountable at completion of project, but where original value does not exceed $300.

0.502 **Expendable Construction Tools and Supplies**—Such expense as may be incurred for tools and supplies consumed by the project or otherwise not accountable at completion of project.

0.503 **Utility Expense**—Such expense as may be incurred for items such as purchased water, gas, power, etc., consumed by the project.

0.504 **Clean-Up**—Such expense as may be incurred to maintain good housekeeping during construction and final clean-up of the project at its completion.

Item No. 0.600 Equipment Expenses

0.601 **Equipment Rentals**—Such expense as may be incurred for equipment rentals whose charges cannot be distributed to direct cost. Freight on equipment to and from site is included in this account.

0.602 **Autos and Pickups**—Such expense as may be incurred for Autos and Pickups on a rental basis.

0.603 **Gas, Oil and Lubrication**—Such expense as may be incurred for all equipment, autos and pickups employed by the project.

0.604 **Equipment Repairs and Parts**—Such expense as may be incurred for the maintenance of all equipment, autos and pickups both on and off the project.

Item No. 0.700 Legal and Accounting

0.701 **Legal Service**—Such expense as may be incurred for legal service, as employed by the project.

0.702 **Accounting**—Such expense as may be incurred for auditing service, as employed by the project.

0.703 **Depreciable Assets**—For accounting purpose only, to accumulate charges on all depreciable assets purchased for the project, such as tools and equipment, which are non-expendable and whose original value is over $300. All office furniture and equipment purchased for the project is also carried in this account.

0.704 **Surplus Account**—For accounting purposes only, to accumulate charges incurred or derived from handling surplus equipment and material for the project. ##

New Way to Get Relative Volatilities

The relations depicted in a Cox-type of vapor pressure chart are transformed here into one equation. The result is an easier and more accurate method for predicting relative volatilities

Oscar H. Hariu
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RELATIVE VOLATILITIES for pairs of hydrocarbons can be predicted more easily and more accurately now, even though the normal boiling points of the materials are the only information known. The new method is based on the straight line relations depicted in a Cox-type vapor pressure chart. The method is easy to use. It is represented by the following equation:

$$\log_{10} \alpha = [f(t)]\ [f(t_2) - f(t_1)]$$

where α is the relative volatility of one hydrocarbon compared to another, $f(t)$ is a function of the operating temperature, and $f(t_1)$ and $f(t_2)$ are functions of the normal boiling points for the two materials. These temperature functions can be read directly from tables presented here. Being ratios of vapor pressures, the α's are subject to the usual limitations of low pressures and Raoult's Law liquids.

Consider Previous Correlations. A number of methods have been published for estimating the vapor pressure (or ideal) α from boiling points.[2,4,5,6,7,9,10,11,13,14] These methods are listed in Table 1 where they are grouped according to the type of data required, as follows:

1. Normal boiling points and operating temperature.[4,5,9]
2. Normal boiling points only.[2,14]
3. Normal boiling points, operating temperature and pressure.[6]
4. Boiling points at the operating pressure, operating temperature and pressure.[7,13]
5. Vapor pressures of both components.[10,11]

Since the ideal α is a ratio of vapor pressures, once the vapor pressure curves of the two components are defined α becomes a function only of temperature. If the vapor pressure curves can be related mathematically to the two boiling points T_1 and T_2, then the only parameters required to define α are T_1, T_2 and the operating temperature T. Therefore group 1 methods, which use these three variables, should be of general utility, regardless of the number of components present and the operating pressure. However, it is shown that these methods are less accurate than the present method, which is also based on the same three parameters.

Group 2 methods were derived for binary mixtures at atmospheric pressure only.

The methods in groups 3 and 4 specify too many variables. Specifying both the operating pressure and the temperature, limits one to binary mixtures of fixed composition. Practically, however, for close-boiling binaries, not much error is introduced by using for T an average of the two boiling points at pressure P. Another disadvantage of these methods is that vapor pressure curves or tables are required to find the boiling points at P.

Group 4 methods are useful for calculating an accurate α of a binary at a specified pressure from vapor pressure tables which list boiling points at fixed increments of pressure, such as the API-44 tables.[15] Otherwise, to get α directly from such tables requires interpolation to find the vapor pressures at the same temperature.

Group 5 methods are simply tools for interpolating or extrapolating α from values at known temperatures.

How the Equation Is Derived. Since the ideal α is simply a ratio of two vapor pressures, independent of total pressure, the equation sought is one which expresses the two vapor pressures as a function of temperature, with the two components characterized by their normal boiling points.

The vapor pressure equation selected, because of its simplicity, was that developed for hydrocarbon Cox chart lines by Davis[1]

$$\log p = A + \frac{B}{t + 382}. \qquad (1)$$

Other vapor pressure correlations, such as the Esso 53-12

TABLE 1—Previous Methods for Calculating α

Equation	Remarks	Reference
Group 1; Require T_1, T_2 and T		
$\log \alpha = \frac{5.0\,(T_2-T_1)}{T}$		(4)
$\log \alpha = \frac{T-T_1}{T}\log\frac{T_1}{1.8} + \frac{T_2-T}{T}\log\frac{T_2}{1.8} + \frac{T_2-T_1}{T}\log R$		(5)
(a) $\log \alpha = 4.85\,\frac{(T_2-T_1)}{T}$	General	(9)
(b) $\alpha_c = 1 + \frac{T_2-T_1}{19.0 + .0633T}$	Close-boiling	
(c) $\alpha_w = 1 + \alpha_c\,(3.81 + 2.3 \log T)\,\frac{T_2-T_1}{T}$	Wide-boiling	
Group 2; Require T_1 and T_2 only.		
Nomograph based on equation in another reference [13] at P = 760.	Limited to binaries at P = 760	(2)
$\log \alpha = \frac{8.91\,(T_2-T_1)}{T_2+T_1}$	Limited to binaries at P = 760	(14)
Group 3; Require T_1, T_2, T and P		
$\log \alpha = (9.9-1.70 \log P)\,\frac{T_2-T_1}{T}$	Specified for phenols. Limited to binary of fixed composition to set both P and T	(6)
Group 4; Require Boiling Points at P, T and P		
Nomograph based on equation in another reference[12]; P = variable	Limited to binary of fixed composition to set both P and T. Requires V.P. data.	(7)
$\log = \frac{T_2'-T_1'}{T}\,(7.30-1.15 \log P + \frac{T}{322 \log P})$ (T' = B.P. at P, °R)	Same as (7)	(13)
Group 5; Require Vapor Pressure Data		
$\log \alpha = B/T - \gamma$	Requires V.P. at two temperatures	(10)
Not given in abstract	Requires V.P. of two at one temp. Limited to low α and parallel V.P. curves.	(11)

* Original equations changed to basis of:
- $\log_{10}$
- boiling points, T_2 and T_1 in °R.
- operating temperature T in °R.

About the Author

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chart,[12] are more accurate but yield equations which are too unwieldy for manual calculations.

Expressing α as the ratio of the vapor pressures of components 1 and 2 at temperature t

$$\log p_1 - \log p_2 = \log (p_1/p_2) = \log \alpha = A_1 - A_2 + \frac{B_1 - B_2}{t + 382} \qquad (2)$$

Since all Cox chart lines go through a common convergence or "infinite" point, p_{oo} and t_{oo}, the coordinates of the normal boiling point (t_b and P = 760 mm) together with the coordinates of the convergence point can be substituted in Equation (1) to solve for the constants A and B. Thus

$$B = \log\left(\frac{p_{oo}}{760}\right) \cdot \frac{(t_b + 382)\,(t_{oo} + 382)}{(t_b - t_{oo})} \qquad (3)$$

$$A = \log p_{oo} - \frac{B}{t_{oo} + 382} \qquad (4)$$

Then for two components,

$$A_1 - A_2 = -\frac{B_1 - B_2}{t_{oo} + 382} \qquad (5)$$

$$B_1 - B_2 = \log\left(\frac{p_{oo}}{760}\right)(t_{oo} + 382)\left(\frac{t_1 + 382}{t_1 - t_{oo}} - \frac{t_2 + 382}{t_2 - t_{oo}}\right) \qquad (6)$$

Substituting Equations (5) and (6) into Equation (2),

$$\log \alpha = (t_{oo} + 382) \log \left(\frac{p_{oo}}{760}\right)\left(\frac{t_1 + 382}{t_1 - t_{oo}} - \frac{t_2 + 382}{t_2 - t_{oo}}\right)\left(\frac{1}{t + 382} - \frac{1}{t_{oo} + 382}\right) \qquad (7)$$

TABLE 2—Values for the function $f(t_B)$.

t_B, °F	0	10	20	30	40	50	60	70	80	90
0.....	0.1687	0.1739	0.1791	0.1844	0.1897	0.1951	0.2005	0.2060	0.2115	0.2171
100.....	0.2227	0.2284	0.2341	0.2399	0.2458	0.2517	0.2577	0.2637	0.2698	0.2759
200.....	0.2820	0.2882	0.2945	0.3009	0.3073	0.3138	0.3204	0.3270	0.3337	0.3405
300.....	0.3473	0.3542	0.3611	0.3682	0.3753	0.3825	0.3897	0.3970	0.4044	0.4119
400.....	0.4195	0.4272	0.4350	0.4428	0.4507	0.4587	0.4668	0.4750	0.4833	0.4916
500.....	0.5000	0.5085	0.5171	0.5259	0.5348	0.5438	0.5529	0.5621	0.5714	0.5807
600.....	0.5901	0.5997	0.6094	0.6192	0.6292	0.6393	0.6496	0.6600	0.6705	0.6811
700.....	0.6918	0.7026	0.7136	0.7248	0.7362	0.7477	0.7594	0.7712	0.7831	0.7952
800.....	0.8074	$f(t_B) = (t_B + 382)/(2264 - t_B)$								

TABLE 3—Values for the function f (t).

t, °F	f (t)
0.....	19.16
50.....	16.42
100.....	14.52
150.....	12.87
200.....	11.47
250.....	10.29
300.....	9.31
350.....	8.46
400.....	7.71
450.....	7.05
500.....	6.47
550.....	5.95
600.....	5.48
650.....	5.06
700.....	4.67
750.....	4.31
800.....	4.00

$$f(t) = \left(\frac{8555}{t + 382}\right) - 3.233$$

TABLE 5—Comparison of Predicted α with Previous Methods

Method	Predicted α's for Systems from Table 4						Remarks
	4	5	10	12	16	23	
Group 1.							
(4)	2.05	1.062	7.6	1.49	20.6	1.22	
(5)	1.94	1.058	6.3	1.42	16.8	1.21	
(9) (a)	2.01	1.060	7.1	1.47	18.7	1.21	General
(b)	1.70	1.059	2.84	1.36	3.98	1.22	Close-boiling, α_c
(c)	2.10	1.058	5.8	1.48	11.9	1.23	Wide-boiling, α_w
Group 2.							
(2)	.....	.....	.....	.....	.....	.....	Does not apply; P‡ 760
(14)	.....	.....	.....	.....	.....	.....	Does not apply; P‡ 760
Group 3.							
(6)	1.96	1.062	11.0	1.47	27.8	1.26	Assumed 50/50 molal binary.
Group 4.							
(7)	.....	.....	.....	.....	.....	.....	Insufficient data
(13)	.....	.....	.....	.....	.....	.....	Insufficient data
Group 5.							
(10)	.....	.....	.....	.....	.....	.....	Insufficient data
(11)	.....	.....	.....	.....	.....	.....	Insufficient data
From vapor Pressure	1.961	1.060	8.0	1.41	28.1	1.26	
Method Herein	1.966	1.060	7.7	1.44	26.4	1.30	

TABLE 4—Comparison of Predicted α with Actual Vapor Pressure

System	Components 1	Components 2	N.B.P., °F 1	N.B.P., °F 2	Temp., °F	α From Vapor Pressure P., mm. Hg. 1	α From Vapor Pressure P., mm. Hg. 2	α	α From f (t) Equation	Percent Deviation	Source of V.P. Data
1....	iso-pentane	n-pentane	82.1	96.9	85	800	601	1.331	1.333	+0.2	(15)
2....	n-pentane	n-hexane	96.9	155.7	99	788	250	3.15	3.13	—0.7	(15)
3....	3 methyl hexane	3 ethyl pentane	197.5	200.2	195	732	700	1.046	1.042	—0.4	(15)
4....	toluene	ethyl-benzene	231.12	277.14	278	1500	765	1.961	1.966	+0.3	(15)
5....	ethyl benzene	para-xylene	277.14	281.03	280	800	755	1.060	1.060	0.0	(15)
6....	cyclo-hexane	methyl cyclohexane	177.3	213.7	108	201	100	2.01	2.08	+4.0	(15)
7....	cyclo-hexane	methyl cyclohexane	177.3	213.7	188	907	500	1.81	1.84	+1.7	(15)
8....	1, 1 dimethyl cyclohexane	ethyl cyclohexane	247.1	269.2	266	1000	725	1.380	1.390	+0.7	(15)
9....	2 methyl pentane	n-hexane	140.5	155.7	156.5	999	771	1.283	1.30	+1.6	(15)
10....	n-hexane	n-octane	155.7	258.2	122	400	50	8.0	7.7	—4.4	(15)
Algebraic ave. dev.										+0.3	
Absolute ave. dev.										1.4	
11....	psuedo–components		100	105	120	1060	980	1.09	1.10	+0.9	(12)
12....	psuedo–components		100	120	120	1070	760	1.41	1.44	+2.1	(12)
13....	psuedo–components		100	120	212	4100	3120	1.32*	1.34	+1.5	(12)
14....	psuedo–components		300	320	200	135	93	1.46	1.44	—1.4	(12)
15....	pseudo–components		300	320	600	16,700	13,900	1.20*	1.19	—0.8	(12)
16....	psuedo–components		300	500	300	760	27	28.1	26.4	—6.0	(12)
17....	psuedo–components		300	500	700	32,300	5,850	5.5*	5.2	—5.4	(12)
18....	psuedo–components		500	510	200	1.82	1.41	1.29	1.25	—3.1	(12)
19....	psuedo–components		500	510	400	180	150	1.20	1.16	—3.3	(12)
20....	psuedo–components		732	752	680	410	320	1.28	1.29	+0.8	(12)
21....	psuedo–components		732	752	500	25	18	1.39	1.41	+1.4	(12)
22....	pseudo–components		780	800	300	.043	.026	1.66	1.68	+1.2	(12)
23....	psuedo–components		780	800	700	290	230	1.26	1.30	+3.2	(12)
Algebraic ave. dev.										—0.9	
Absolute ave. dev.										3.1	

* Valid only if diluted with heavier components to reduce the total pressure.

$$\log \alpha = \log \left(\frac{p_{oo}}{760}\right)\left(\frac{t_{oo}+382}{t+382}-1\right)\left(\frac{t_1+382}{t_1-t_{oo}}-\frac{t_2+382}{t_2-t_{oo}}\right) \quad (8)$$

Substituting $p_{oo} = 1.3 \times 10^6$ mm and $t_{oo} = 2264°$ F. as recommended by Driesbach[3] for aliphatic hydrocarbons results in the final equation

$$\log \alpha = \left(\frac{8555}{t+382}-3.233\right)\left(\frac{t_2+382}{2264-t_2}-\frac{t_1+382}{2264-t_1}\right). \quad (9)$$

Equation (9) can be expressed as

$$\log_{10} \alpha = [f(t)]\ [f(t_2) - f(t_1)], \quad (10)$$

$$\text{where } f(t) = \frac{8555}{t+382} - 3.233 \quad (11)$$

and $f(t_2)$ and $f(t_1)$ are identical functions

$$f(t_B) = \frac{t_B+382}{2264-t_B}. \quad (12)$$

Table 2 lists values of $f(t_B)$ at 10° intervals of t_B from 0 to 800° F. Table 3 gives values of $f(t)$ for 50° intervals of t from 0 to 800° F. Linear interpolation is permissible with both tables.

Equation (9) can also be used directly in a computer.

Sample Calculation Given. Determine α at 200° F. and 600° F. between components 1 and 2 whose normal boiling points are 300° F. and 320° F. respectively.

Component	t_B	$f(t_B)$
1	300	0.3473
2	320	0.3611

At 200°, $f(t) = 11.47$

$$\log \alpha = [f(t)]\ [f(t_2) - f(t_1)]$$
$$= (11.47)\ (0.3611 - 0.3473)$$
$$= 0.158$$
$$\alpha = 1.44$$

Compared with $\alpha = 1.46$ from actual vapor pressure.[12]

At 600°, $f(t) = 5.48$

$$\log \alpha = (5.48)\ (0.3611 - 0.3473)$$
$$= 0.0756$$
$$\alpha = 1.19$$

Compared with $\alpha = 1.20$ from actual vapor pressures.[12]

Comparison With Actual Vapor Pressure. Table 4 compares α's calculated by the present method with those from vapor pressures. The first 10 systems use API-44[15] data, the others, Esso 53-12 vapor pressures.[12] The systems were picked at random to cover a wide range of α's and deviation of temperature from the normal boiling points.

Compared with API-44 vapor pressure data, the algebraic average deviation of α was +0.3% and the absolute average 1.4%. With Esso 53-12 values, these deviations were —0.9 and 3.1%, respectively. As expected, deviations were largest for high α's and temperatures farthest removed from the average of the normal boiling points. This shows that the Cox chart equation does not exactly fit the vapor pressure data, but the resultant accuracy is sufficient for most low-pressure distillation calculations.

Among the API-44 data are those for paraffins, aromatics and naphthenes. No significant effect of hydrocarbon type on accuracy is seen, although the convergence point for paraffins was used in the derivation.

Comparison With Previous Methods. Table 5 compares α's predicted by the present method with those by previous methods. Six systems were picked from Table 4 to cover a range of conditions.

Compared with the group 1 methods, which are also based on the normal boiling points and operating temperature, the present method predicts values closer to the vapor pressure α's in almost every case and much more accurately with the high α's, 8.0 and 28.1.

Group 2, 4 and 5 methods could not be used because 2 is only for atmospheric pressure and there were insufficient data for groups 4 and 5.

Method (6) in group 3, which was developed for phenols, is surprisingly accurate for hydrocarbons over a wide range of α's. However, this method is limited to binary mixtures; further, a 50/50 molal mixture had to be assumed in order to relate P and T.

NOMENCLATURE

A	Constant in Cox chart equation, dimensionless.
B	Constant in Cox chart equation, °F.
P	Total pressure, mm. Hg.
R	Gas constant, 82.048 atm. $cm^3/°K$ gm. Mol.
T	Temperature, °R.
T_1 or T_2	Boiling point at 760 mm. of components 1 and 2, °R.
log	Logarithm to the base 10.
p	Vapor pressure, mm. Hg.
t	Temperature, °F.
t_B	Boiling point at 760 mm. of any component, °F.
t_1 and t_2	Boiling point at 760 mm. of components 1 and 2, °F.
α	Ideal relative volatility = p_1/p_2
β, γ	Constants in Griswold Equation (10).

SUBSCRIPTS

1, 2	Components 1 and 2.
oo	Refers to convergence point on Cox chart.
B	Boiling point.

LITERATURE CITED

[1] Davis, D. S. *Ind. Eng Chem.* 17 735 (1925).
[2] Davis, D. S. *Chem. Inds.* 61 872 (1947).
[3] Dreisbach, R. R. "P-V-T Relationships of Organic Compounds," 3rd Ed. Handbook Publishers, Sandusky, Ohio (1952).
[4] Edgeworth-Johnstone, R. *J. Inst. Pet. Tech.* 25 558 (1939).
[5] Edgeworth-Johnstone, R. *Ind Eng. Chem.* 35 826 (1943).
[6] Ellis, S. R. M. *Ind. Chem.* 28 296 (1952).
[7] Frische, W. C. *Chem. Engr.* 56 118 (July 1949).
[8] Frische, W. C. Petroleum Refiner 29 137 (1950).
[9] Griswold, J. *Ind. Eng. Chem.* 35 247 (1943).
[10] Griswold, J. *Ind. Eng. Chem.* 35 826 (1943).
[11] Haldenwanger, H. *Chem.-Ing. Tech.* 22 8 (1950).
[12] Maxwell, J. B. and Bonnell, L. S. "Vapor Pressure Charts for Petroleum Hydrocarbons," Esso Res. and Eng. Co., Linden, N.J. (1955).
[13] Melpolder, F. W. and Headington, C. E. *Ind. Eng. Chem.* 39 763 (1947).
[14] Rose, A. *Ind. Eng. Chem.* 33 594 (1941).
[15] Rossini, F. D. et al. "Selected Values of —— Properties of Hydrocarbons ——," Carnegie Press, Pittsburgh (1953) (API-44 data).

Operator's Handbook for Gasoline Plants

PART 11—Exchangers and Tanks. One of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant

Manufacturing Department,
Tennessee Oil Refining Co.
A Division of Tennessee Gas Transmission Co., Houston

EXCHANGERS AND TANKS are two types of equipment that play an important part in a typical natural gasoline plant. Exchangers provide an economical method of transferring heat from one fluid to another. Tanks are used to contain the various fluids during processing and storage.

EXCHANGERS

Heating and cooling a product stream involves the transferring of heat from one fluid to another through a metal wall. The fluids on either side of this metal wall may be both liquids, both gases, liquid and a gas, or fluids in the process of condensing or vaporizing.

Many heat exchangers are the tube and shell type. These exchangers consist of an outer metal shell that contains one fluid, while the other fluid passes through tubes inside this shell. Heat is transferred from one fluid to another as they follow their path through the exchanger.

Usually bundles of tubes are rolled into a single tube sheet so that the heating or cooling fluid enters half the tubes and returns through the other half. These bundles are called U-tube or hairpin. Many other structural types of exchangers are built, but the operator need not know them. The primary aim of any exchanger is to obtain a high heat transfer rate between two fluids without exceeding the allowable pressure drop through the equipment.

Number of Passes. Usually the flow of fluid through the tubes is arranged so that the fluid passes through one section of tubes and then returns through another section of tubes. As many as 16 passes of this type have been used. Today the trend is toward one or two-pass exchangers because of mechanical difficulties with multi-passes.

The single-tube exchanger is being used more in new gasoline plants. This equipment consists of a small pipe inside a larger pipe and is sometimes called a double-pipe exchanger. Advantages of this equipment are:

1. Various numbers of these units may be easily disconnected and reassembled to meet changes in operating conditions.
2. One unit can be removed from service for cleaning or tube repair without interrupting plant operations to any great extent.
3. The size of the units permits easier handling and better maintenance.

Fluid in Tubes. In most cases the fluid passed through the tubes is cooling water. This is done so that the exchanger may be cleaned periodically by removing the cover flange and mechanically reaming out the tubes to remove any deposits that interfere with heat transfer. Even water that has been treated for hardness will eventually build up a deposit on the tube wall. This must be removed whenever the build up of scale materially reduces the heat exchange capacity of the exchanger. When water is not used in the exchanger, the fluid that is more likely to cause fouling should be put through the tube side of the exchanger.

Figure 57 shows a floating head type exchanger. Generally water will enter the bottom tube flange and leave through the top tube flange after making a pass through the bottom section and then through the top. The shell fluid generally enters through the top shell inlet flange, passes along its predetermined baffled path and leaves through the outlet shell flange. This type of exchanger is used when the temperature differential between the two fluids is extremely high. The floating head permits the tubes to expand or contract to a differ-

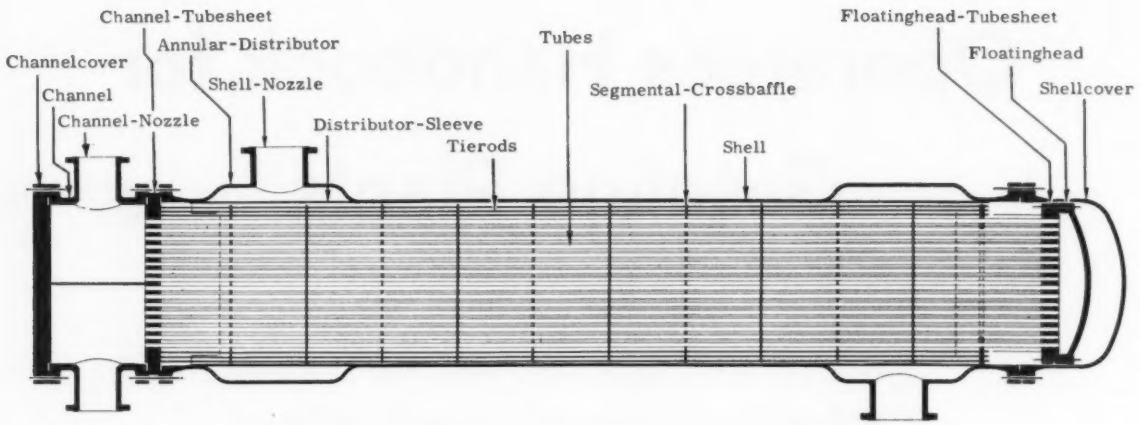

FIGURE 57—Cutaway for a typical exchanger shows floating head and two passes on tube side. Many structural variations to this type are built.

ent degree from that of the shell without causing undue stress in the metal.

Materials of Construction. The fluids being handled, pressure, temperature, and economic requirements will determine the materials used in the construction of a heat exchanger. Alloys are more costly than carbon steel, but in corrosive service usually prove to be more economic. Carbon steel, stainless steel, copper, nickel, aluminum and other special alloys are used in part or throughout the entire exchanger according to the service required.

Tubes. The most popular sizes of tubes used in heat exchangers are ⅝-inch and ¾-inch. These sizes produce the best performance characteristics and prove to be the most economical. Tubing used for heat exchangers is either seamless or welded. The seamless tube is usually extruded while the welded tube is rolled into a cylindrical shape and welded by a precisely controlled automatic process.

Cooling Towers. A cooling tower is another form of heat exchanger. Generally a stream of hot water is cooled by exchange of sensible and latent heat and water vapor with a stream of relatively cool dry air. Towers are of redwood construction and are generally built away from buildings perpendicular to the prevailing summer wind. Most towers now are the induced draft (fan on top) type. This insures adequate and uniform cooling regardless of wind conditions.

Hot water is pumped to the top of the tower and enters a distribution system that covers the top surface of the tower. A regulated amount of water then falls through nozzles and is broken up into small drops. These drops then fall countercurrent to the air onto slat-type grids. With countercurrent flow the warmest water contacts the most humid air and the coldest water contacts the dryest air. This assures maximum cooling. After their cooling the drops are collected in the basin of the tower and pumped into the process area for use in the heat exchangers. The hot water then returns to the cooling tower where the whole process is repeated in a continuous flow operation.

Treatment of the cooling tower water is necessary to kill biological growth which attacks the tower wood and which could plug tower nozzles. Another treatment chemical is added to protect the water piping from corrosion.

TANKS

The pressure range of tanks and vessels used in natural gasoline plants ranges from atmospheric to pressures in excess of 2,000 psi. Steel is practically the only available material that possesses the necessary physical properties to contain fluids handled. Each tank or vessel in the plant is designed primarily on these five conditions:

1. Size of the tank
2. Working pressure
3. Working temperature
4. Corrosive action of the contained fluid
5. Type of operation

In extremely high pressure design other factors such as vertical or horizontal installation, number and size of openings, etc., enter into the design calculations.

Each product produced in the plant is stored in a tank with a pressure rating suitable for its vapor pressure. This table shows the design pressure of the tanks commonly used for product storage.

Product	Design Pressure PSIG
Propane	225
Isobutane	95
Normal Butane	50
LPG	150
Gasoline	Atmospheric

TO BE CONTINUED

Compressibility Factors for Super Pressures and Temperatures

Use these charts for superpressures and high temperatures for individual gases or for gaseous mixtures. These are especially good for hydrogen and hydrogen mixtures

John M. Lenoir*
C F Braun & Company, Alhambra, Calif.

PUBLISHED COMPRESSIBILITY FACTOR charts usually do not adequately cover the range of conditions where the compressibility factor is greater than 1.00, and the compressibility factor for hydrogen or hydrogen mixtures do not fit the conventional generalized charts. Here are new charts for the range of high compressibility factors. In addition, here is a convenient way to handle hydrogen mixtures with improved accuracy.

The usual way to predict pressure-volume-temperature relations of gases utilizes the ideal gas law with an empirical correction factor, z, called the compressibility factor, as,

$$PVM = zWRT \qquad (1)$$

where

$$z = f(T_R, P_R) \qquad (2)$$

To compute gas density, equation 1 may be written

$$\rho = \frac{MP}{10.73\ zT} \qquad (3)$$

Values of z can be obtained from many available compressibility factor charts.[6, 9, 14, 16, 26, 29, 32] Most of these charts cover a range of reduced temperatures below 2.5 and reduced pressures of below 8, a range that includes most applications. Where these limits were exceeded, emphasis was placed on the chart areas giving values of compressibility factors below 1.00. It is often difficult to estimate compressibility factors above one from these charts that have wide limits of reduced pressure and reduced temperatures. It is convenient to have compressibility charts that cover the high reduced-temperature range, and in general, the region of high compressibility factors.

Figures 1, 2, 3, and 4 show compressibility factors above a value of 1.00. These charts are based upon PVT measurements on components of nitrogen, methane, ethane, ethylene, propylene, propane, carbon monoxide, carbon dioxide, and nitric oxide.

It has been well established that the compressibility factors for hydrogen, as well as neon, helium, and argon, do not fit the usual generalized compressibility factor charts.[15, 18, 26, 27] Morgan and Childs[26] suggested that the hydrogen compressibility factors be obtained from the generalized compressibility-factor chart using fictitious critical constants. These special critical constants depend upon the operating temperature. Figure 5 shows these critical constants termed, Effective Critical Constants. Values are shown over a very wide range of temperatures. The values of critical constants were obtained independent of the Morgan and Childs values. The use of effective critical constants works very well in predicting compressibility factors for pure hydrogen. Effective critical constants are also useful to predict compressibility factors for hydrogen-rich mixtures. The pseudo-critical method of Kay[12] is commonly used to predict gas mixture density. The use of effective critical constants for hydrogen permits adaptation to Kay's method without additional complication.

The validity of Figures 1 through 4 in conjunction with Figure 5 is illustrated in Table 1. The prediction accuracy for pure gases averages 0.4-percent of measured values. For gas mixtures the average discrepancy is 2.3 percent, with a maximum deviation of 8 percent. These figures depended upon a survey of many predictions of which Table 1 shows only a few values selected at random. Joffe[11] has pointed out that Kay's method is only an excellent first approximation, and cannot be

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See new charts on following pages ▶

New charts for range of high

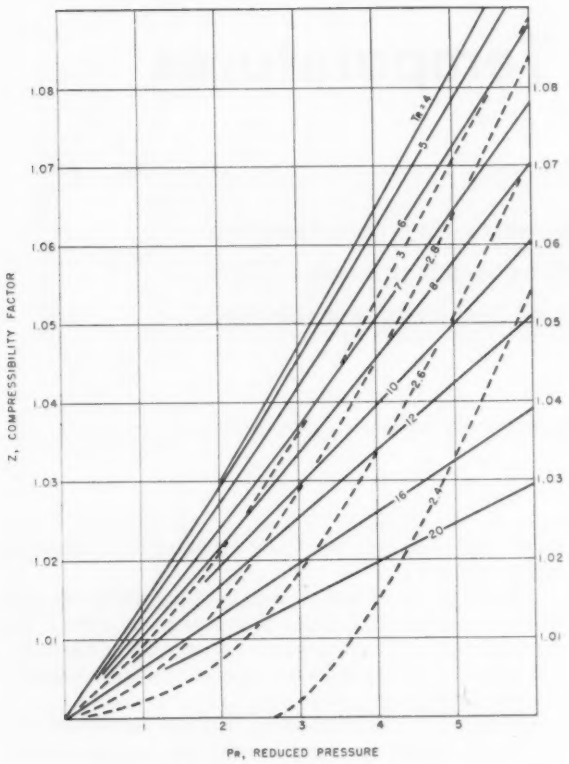

FIGURE 1—$P_R = 0$ to 6

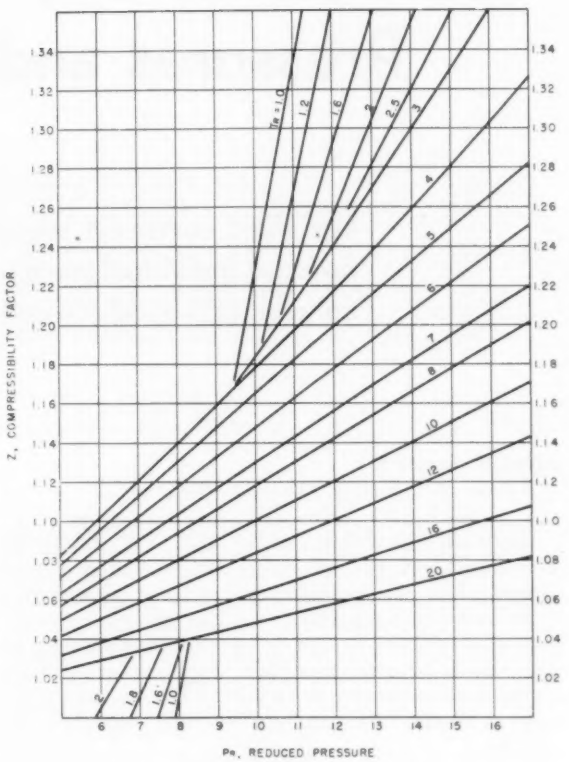

FIGURE 2—$P_R = 5$ to 17

expected to give precise results. Other methods[3,10,11] of predicting gas densities of mixtures are usually more cumbersome to use. Kay's method is popular because of its simplicity and because it can be counted on to give a reasonably accurate value of density.

Figures 1 through 4 are suggested as general charts for getting compressibility factors of numerical value exceeding 1.00. Figure 5 is presented as a way to get effective critical constants for hydrogen, permitting the simple adaptation of hydrogen to the usual methods of predicting gas densities.

USE OF CHARTS

Pure Hydrogen. Let's predict the compressibility factor of hydrogen at 166.5 F and 8,340 psia. From Figure 5, $T^*_c = 83°$ R, and $P^*_c = 327$ psia. $T_R = (460 + 166.5)/83 = 7.55$. $P_R = 8340/327 = 25.5$. Figure 3 shows a compressibility factor of 1.315. Michels, Nijhoff, and Gerver[22] measured a compressibility factor of 1.318 for this condition.

Pure Ethylene. What is the compressibility factor of ethylene gas at 302 F and 44,800 psia? Critical constants are 510° R and 750 psia. $T_R = (460 + 302)/510 = 1.50$. $P_R = 44{,}800/750 = 59.7$. From Figure 4, $z = 4.26$. Michels and Geldermans[19] measured a z of 4.30.

Mixtures. Suppose there is a mixture of 51.74 mole percent hydrogen and 48.76 mole percent nitrogen at 572 F and 14,700 psia. Let's get the compressibility factor using the method of Kay.[12] It is convenient to use a table to compute pseudo-critical constants.

Gas	T_c	P_c	x	xT_c	xP_c
Hydrogen	83	330	0.5174	42.9	171
Nitrogen	217	492	0.4876	105.9	240
				$T_{sc} = 148.8$	$P_{sc} = 411$

$T_R = (460 + 572)/148.8 = 6.95$. $P_R = 14{,}700/411 = 35.7$. From Figure 3, $z = 1.48$. Wiebe and Gaddy[34] measured $z = 1.457$.

NOMENCLATURE

M	Molecular weight	T_c	True critical temperature, °Rankine
P	Operating Pressure, psia	T^*_c	Effective critical temperature for hydrogen, °Rankine
P_c	True critical pressure, psia	T_R	Reduced temperature, T/T_c or T/T^*_c or T/T_{sc}
P^*_c	Effective critical pressure of hydrogen, psia	T_{sc}	Pseudo-critical temperature, °Rankine
P_R	Reduced pressure, P/P_c or P/P^*_c or P/P_{sc}	V	Volume, ft³
P_{sc}	Pseudo-critical pressure, psia	W	Weight, lbs
R	Gas constant, 10.73 psia ft³ lb-mole/lb °Rankine	x	Mole fraction
T	Operating temperature, °Rankine	z	Compressibility factor
t	Operating temperature, F	ρ	Density, lb/ft³

How valid are

compressibility factors...

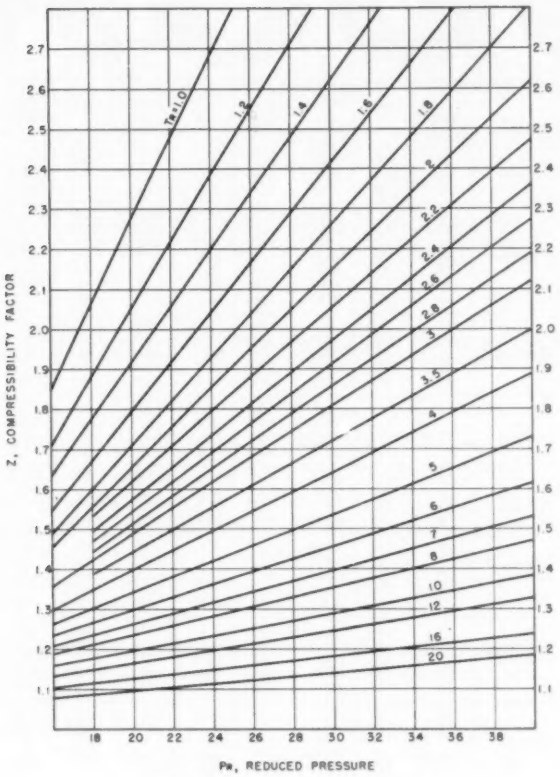

FIGURE 3—$P_R = 16$ to 40

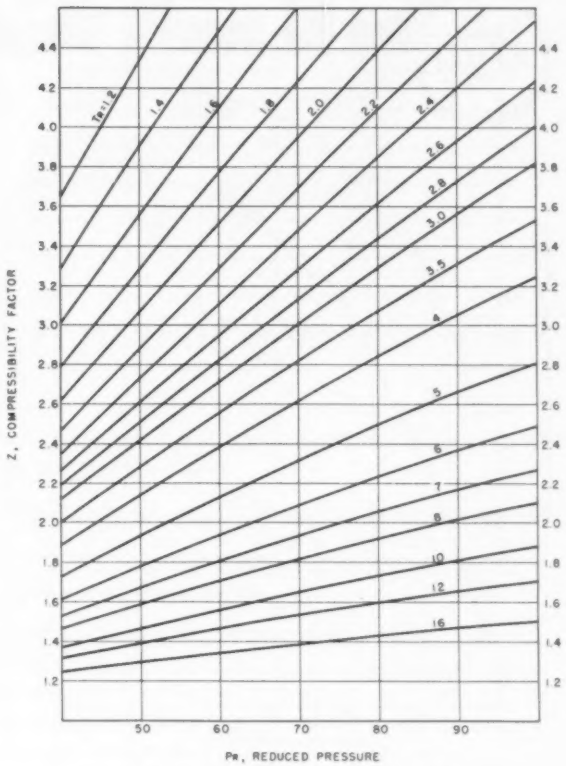

FIGURE 4—$P_R = 40$ to 100

LITERATURE CITED

[1] Barkelew, C. H., Valentine, J. H., and Hurd, C. O., Thermodynamic Properties of Ethane, Chem. Eng. Prog., 43, 27 (1947).

[2] Bartlett, E. P., Cupples, H. L., and Tremearne, T. H., Compressibility Factors of Hydrogen, Nitrogen, and Their 3:1 Mixture, J. Am. Chem. Soc., 50, 1275 (1928).

[3] Bartlett, E. P., Hetherington, H. C., Kvalness, H. M., and Tremearne, T. H., Compressibility of Isotherms of Hydrogen, Nitrogen, and Their 3:1 Mixture at Low Temperatures, J. Am. Chem. Soc., 52, 1363 (1930).

[4] Benedict, M., PVT Properties of Nitrogen at High Density, J. Am. Chem. Soc., 59, 2224 (1937).

[5] Bennett, C. O., and Dodge, B. F., Compressibilities of Mixtures of Hydrogen and Nitrogen Above 1,000 Atmos, Ind. Eng. Chem., 44, 180 (1952).

[6] Brown, G. G., Souders, M., and Smith, R. L., Pressure-Volume-Temperature Relations of Paraffin Hydrocarbons, Ind. Eng. Chem., 24, 513 (1932).

[7] Deming, W. E., and Shupe, L. E., Physical Properties of Nitrogen and Carbon Monoxide Gases, Phys. Rev., 37, 638 (1931), 38, 2245 (1931).

[8] Deschner, W. W., and Brown, G. G., PVT Relations of Propane, Ind. Eng. Chem., 32, 836 (1940), 33, 263 (1940).

[9] Dodge, B. F., Physico-Chemical Factors in High Pressure Design, Ind. Eng. Chem., 24, 1353 (1932).

[10] Gilliland, E. R., PVT Relations of Gaseous Mixtures, Ind. Eng. Chem., 28, 212 (1936).

[11] Joffe, J., Prediction of PVT Properties of Gases from Critical Data, Chem. Eng. Prog., 45, 160 (1949).

[12] Kay, W. B., Density of Hydrocarbon Gases and Vapors, A Correlation, Ind. Eng. Chem., 28, 1014 (1936).

[13] Kvalnes, H. M., and Gaddy, V. L., Compressibility Isotherms of Methane, J. Am. Chem. Soc., 53, 394 (1931).

[14] Lewis, W. K., and Luke, C. D., Properties of Hydrocarbon Mixtures at High Pressures, Trans. ASME, PME 54-8, 55 (1932).

[15] Maslan, F. D., and Littman, T. M., Compressibility Charts for Hydrogen, Ind. Eng. Chem., 45, 1566 (1953).

[16] Maxwell, J. B., Data Book on Hydrocarbons, Van Nostrand Co., 1950.

[17] Matthews, C. S., and Hurd, C. O., Properties of Methane, Trans. Amer. Inst. Chem. Engrs., 42, 55 (1946).

[18] Meissner, H. P., and Seferian, R., PVT Relations of Gases, Chem. Eng. Prog., 47, 579 (1951).

[19] Michels, A., and Geldermans, M., Isotherms of Ethylene, Physica, 9, 967 (1942).

[20] Michels, A., and Goudeket, M., Compressibilities of Hydrogen, Physica, 8, 347 (1941).

[21] Michels, A., Lupton, J. M., Wassenaar, T., and De Graaf, W., Isotherms of Carbon Monoxide, Physica, 18, 121 (1952).

[22] Michels, A., Nijhoff, G. P., and Gerver, A. J. J., Isothermal Measurement of Hydrogen Between 0 and 100 C and Up to 1,000 Atmos, Ann d Physik, 12, 562 (1932).

[23] Michels, A., and Wassenaar, T., Isotherms of 3:1 Hydrogen-Nitrogen Mixture. Appl. Sci. Research, A1, 258 (1949), A1 378 (1949).

[24] Michels, A., Wassenaar, T., Wolkers, G. J., De Graaf, W., and Louwerse, P., Isotherms of Ammonia-Nitrogen-Hydrogen Mixtures, Appl. Sci. Research, A3, 1 (1951).

[25] Michels, A., Wouters, H., and DeBoer, J., Isotherms of Nitrogen, Physica, 3, 585 (1936).

[26] Morgen, R. A., and Childs, J. H., Empirical Correction for Compressibility Factor and Activity Coefficient Curves, Ind. Eng. Chem., 37, 665 (1945).

[27] Newton, R. H., Activity Coefficients for Gases, Ind. Eng. Chem., 27, 302 (1935).

[28] Olds, R. H., Reamer, H. H., Sage, B. H., and Lacey, W. N., Volumetric Behavior of Methane, Ind. Eng. Chem., 35, 922 (1943).

[29] Perry, J. H., Chemical Engineers Handbook, McGraw-Hill Book Co., Ed 3, 1850, ps 205-208.

these charts? ..... turn the page ▶

Accuracy for pure gases averages 0.4% . . .

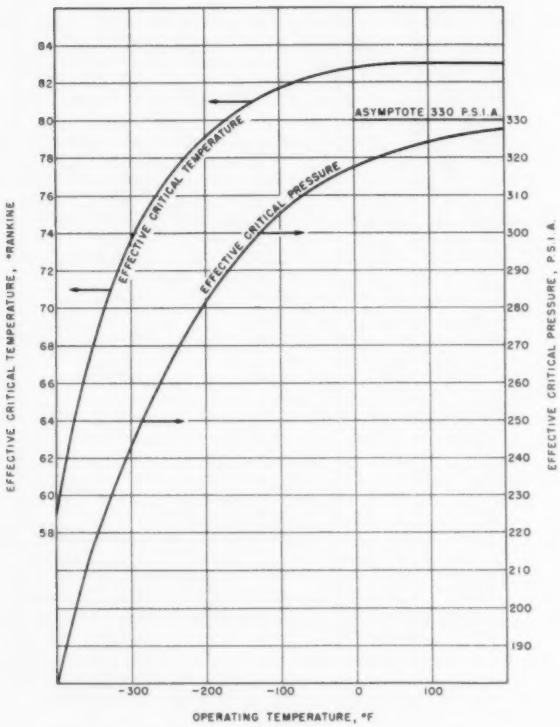

FIGURE 5—Effective critical constants hydrogen

Larger copies of the figures can be obtained from C F Braun & Company, 1000 South Fremont, Alhambra, Calif.

[30] Reamer, H. H., Olds, R. H., Sage, B. H., and Lacey, W. N., Volumetric Behavior of Ethane, Ind. Eng. Chem., 36, 956 (1944).

[31] Sage, B. H., Olds, R. H., and Lacey, W. N., Two Gaseous Mixtures Containing Hydrogen and Nitrogen, Ind. Eng. Chem., 40, 1453 (1948).

[32] Su, G. J., Modified Law of Corresponding States for Real Gases, Ind. Eng. Chem., 38, 803 (1946).

[33] Vaughan, W. E., and Graves, N. R., PVT Relations of Propylene, Ind. Eng. Chem., 32, 1252 (1940).

[34] Wiebe, R., and Gaddy, V. L., Compressibilities of Hydrogen and Mixtures of Hydrogen and Nitrogen, J. Am. Chem. Soc., 60, 2300 (1938).

[35] Woolley, H. W., Scott, R. B., and Brickwedde, F. G., Compilation of the Properties of Hydrogen and Deuterium, J. Research Nat. Bur. Standards, 41, 379 (1948).

[36] York, R. and White, E. F., Thermodynamic Properties of Ethylene, Trans. Amer. Inst. Chem. Engrs., 40, 227 (1944).

About the Author

Dr. John M. Lenoir is a professor of chemical engineering at the University of Southern California. He received his Ph.D. degree from the University of Illinois in 1949, and spent four years as an assistant and associate professor at the University of Arkansas. He also taught at the University of Denver for two years. Dr. Lenoir has worked as an engineer specializing in research for American Oil Co. and Lockheed Aircraft Corp. Most recently, he had been with C F Braun & Co, which he joined in 1951.

Dr. J. M. Lenoir

TABLE 1—Prediction of Compressibility Factors

Gas	Ref.	Temp. F	Press. psia	T_R	P_R	Pred. z	Meas. z	Pct. Dev.
Methane	28	460	1000	2.67	1.49	1.005	1.004	+0.1
	28	460	4000	2.67	5.95	1.075	1.066	+0.8
	28	460	10000	2.67	14.85	1.340	1.329	+0.8
	17	500	1500	2.79	2.23	1.016	1.012	+0.4
Ethylene	19	212	11300	1.32	15.10	1.590	1.588	+0.1
	19	212	23200	1.32	30.85	2.780	2.785	−0.2
	19	212	37200	1.32	49.60	4.04	4.04	0
	19	302	9600	1.50	12.8	1.370	1.360	+0.7
	19	302	18750	1.50	25.0	2.18	2.20	−0.9
	19	302	29000	1.50	38.7	3.07	3.06	+0.3
	19	302	44750	1.50	59.7	4.27	4.30	−0.7
Nitrogen	29	752	881	5.34	1.79	1.025	1.025	0
	29	752	2940	5.34	5.97	1.092	1.092	0
	29	752	7350	5.34	14.9	1.240	1.245	−0.2
	29	752	14700	5.34	29.9	1.500	1.510	−0.7
	29	575	7350	4.55	14.9	1.260	1.270	−0.8
Nitrogen	7	1112	881	6.92	1.79	1.022	1.023	−0.1
	7	1112	2940	6.92	5.97	1.079	1.074	+0.5
	7	1112	7350	6.92	14.9	1.195	1.200	−0.4
	7	1112	17600	6.92	35.8	1.482	1.520	−2.5
Nitrogen	25	302	10910	3.51	22.2	1.500	1.520	−1.3
	25	302	16500	3.51	33.6	1.820	1.842	−1.2
	25	302	29500	3.51	60.0	2.56	2.575	−0.6
	25	302	43500	3.51	88.5	3.28	3.300	−0.6
Carbon Monoxide	7	752	1100	5.0	2.14	1.032	1.039	−0.7
	7	752	8810	5.0	17.4	1.291	1.318	−2.0
	7	752	17600	5.0	34.3	1.620	1.638	−1.1
	21	256	1410	2.96	2.76	1.035	1.042	−0.7
	21	256	4180	2.96	8.20	1.130	1.029	+0.1
Carbon Monoxide	21	256	9000	2.96	17.65	1.410	1.380	+2.2
	21	32	7260	2.03	14.23	1.370	1.375	−0.4
	21	32	11500	2.03	22.55	1.775	1.777	−0.1
	21	32	18600	2.03	36.50	2.45	2.435	+0.6
	21	32	30500	2.03	59.80	3.49	3.459	+0.9
Hydrogen	22	32	1115	5.93	3.48	1.050	1.0478	+0.2
	22	32	3960	5.93	12.4	1.185	1.1816	+0.3
	22	32	8200	5.93	25.6	1.391	1.3906	0
	22	32	10320	5.93	32.3	1.495	1.4957	0
	22	32	16000	5.93	50.0	1.79	1.7715	+1.0
Hydrogen	22	76	1215	6.48	3.75	1.050	1.050	0
	22	76	4310	6.48	13.3	1.183	1.190	−0.6
	22	129	1332	7.1	4.11	1.051	1.049	+0.2
	22	129	4600	7.1	14.2	1.181	1.190	−0.8
	22	129	9800	7.1	30.2	1.395	1.400	−0.4
Hydrogen	22	129	12300	7.1	38.0	1.505	1.500	+0.3
	22	212	1525	8.1	4.65	1.053	1.051	+0.2
	22	212	5450	8.1	16.6	1.191	1.191	0
	22	212	11200	8.1	34.2	1.398	1.400	−0.2
	22	212	14080	8.1	42.9	1.49	1.501	−0.7
Hydrogen	20	302	406	9.2	1.23	1.012	1.010	+0.2
	20	302	7900	9.2	23.95	1.255	1.250	+0.4
	20	302	19300	9.2	58.5	1.60	1.598	0
	20	302	26000	9.2	78.7	1.79	1.790	0
	20	302	29800	9.2	90.2	1.90	1.895	+0.3
59% H_2, 24% N_2, 17% NH_3	24	167	294	2.74	0.57	1.000	1.001	−0.1
	24	167	1470	2.74	2.95	1.020	1.022	−0.2
	24	167	2940	2.74	5.90	1.064	1.056	+0.8
	24	167	3820	2.74	7.66	1.110	1.082	+2.6
	24	167	4410	2.74	8.85	1.143	1.110	+3.0
67% H_2, 26% N_2, 7% NH_3	24	302	284	4.67	0.60	1.003	1.009	−0.6
	24	302	1470	4.67	3.16	1.032	1.041	−0.9
	24	302	2940	4.67	6.27	1.102	1.089	+1.2
	24	302	3820	4.67	8.15	1.136	1.120	+1.4
	24	302	4410	4.67	9.4	1.158	1.140	+1.6
3:1 H_2—N_2	2	32	735	4.22	2.02	1.031	1.027	+0.4
	2	32	4410	4.22	12.2	1.225	1.219	+0.5
	2	32	8820	4.22	24.3	1.49	1.485	+0.3
	2	32	14700	4.22	40.5	1.87	1.875	−0.3
	2	122	735	5.0	2.0	1.031	1.029	+0.2
3:1 H_2—N_2	2	122	4410	5.0	12.0	1.202	1.200	+0.2
	2	122	8820	5.0	24.0	1.425	1.421	+0.3
	2	122	14700	5.0	40.0	1.730	1.760	−0.6
	2	390	735	7.3	1.98	1.024	1.022	+0.2
	2	390	4410	7.3	11.9	1.152	1.151	+0.1
3:1 H_2—N_2	2	390	8820	7.3	23.8	1.302	1.301	+0.1
	2	390	14700	7.3	39.8	1.52	1.52	0
	2	570	735	8.85	1.98	1.021	1.020	+0.1
	2	570	8820	8.85	23.8	1.262	1.262	0
	2	570	14700	8.85	39.8	1.440	1.440	0
25% H_2, 75% N_2	5	77	14700	2.92	32.7	1.915	1.900	+0.8
	5	167	14700	3.41	32.6	1.81	1.79	+1.1
	5	257	14700	3.90	32.6	1.72	1.703	+1.3
50.5% H_2, 49.5% N_2	5	77	14700	3.51	36.0	1.880	1.820	+3.3
	5	167	14700	4.1	35.9	1.77	1.715	+3.2
	5	257	14700	4.7	35.8	1.68	1.640	+2.4

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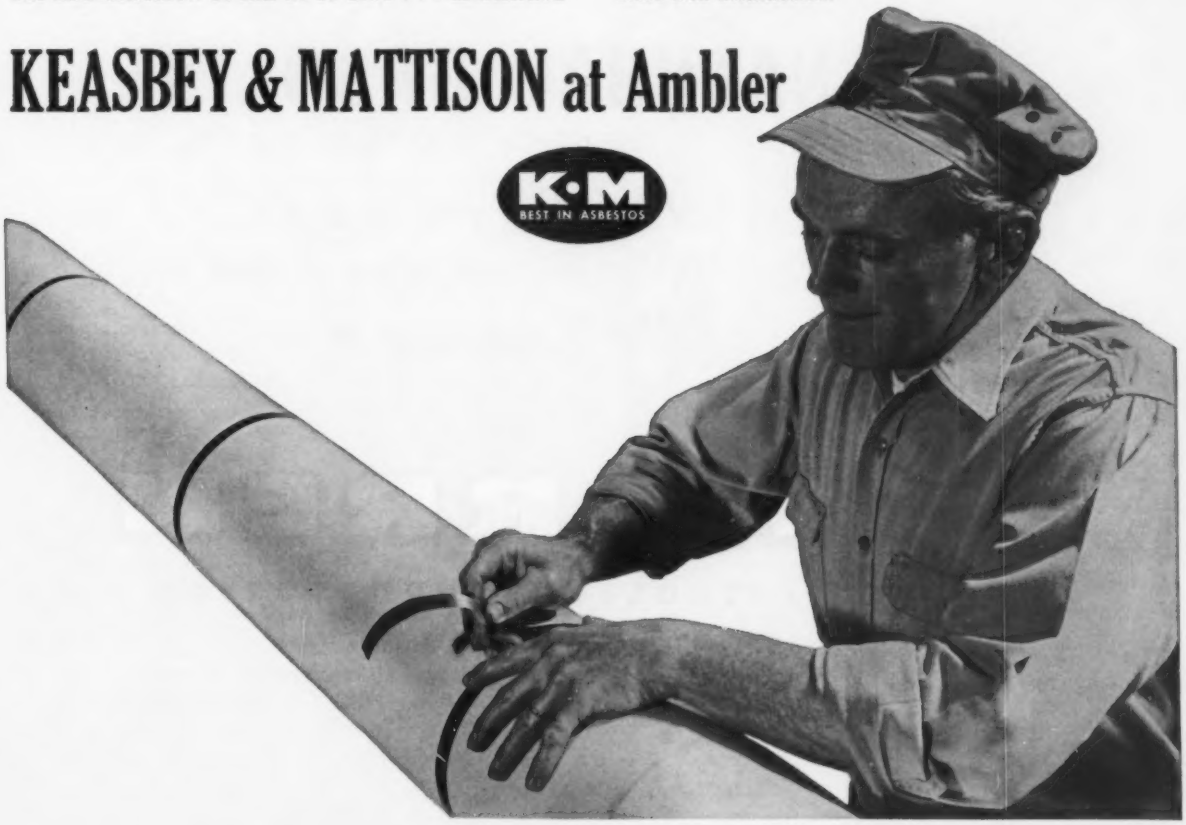

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HOW POWER AFFECTS EMPLOYE APPRAISAL

Employe morale depends a great deal on the way a supervisor handles employe evaluations. You will do well to remember these points whenever you are being appraised—or when you are appraising others

Robert R. Blake and Jane S. Mouton
The University of Texas, Austin

A STUDY of the dynamics of power, shows clear-cut connections between the power distribution of supervisor and subordinate and their relative feelings of satisfaction and responsibility. This was clearly demonstrated last month in Part 3 of this series.

Performance appraisal in another facet of supervisor-subordinate relations. It would be inappropriate to regard it as a separate class of events distinguishable from other relationships that connect supervisors and subordinates. This is only a forewarning which says that in the interests of consistency, if for no other reason, a supervisor can't act one way in the context of work and in a contradictory fashion in counseling a subordinate.

In a management development laboratory, participants experience and compare the ratings and the goals method of performance evaluation. As you will see the ratings method is a 1/0 power relation because all the decisions are entirely in the hands of the supervisor. On the other hand, a goals approach goes in the direction of a .5/.5 power distribution because both members of the pair are collaborating in a common search for solutions to problems. When you come right down to it, it's the difference between a "tell and sell" and a "give and take" situation.

The Experiment. Here is how an employe performance appraisal is handled in a group dynamics laboratory. However, you would do well to remember these principles whenever you are being evaluated or when you are evaluating the work performance of another employe.

Each participant is cast either as a fictitious supervisor named Bob Hayes, or as Fred Winters his subordinate. Then they are briefed on how Fred Winters has been operating in his position. They are also instructed on how to conduct the typical ratings type of performance appraisal. Each participant receives a rating form characteristic of that used by many organizations.

The goals method is described also, and a sample interview outline provided. Then each supervisor conducts two performance review interviews, one according to a ratings approach and one using the goal-setting procedure, each with a different subordinate.

The supervisor, Bob Hayes, is a department head. Four general foremen report to Bob. In turn each general foreman has three or four division foremen reporting to him. One general foreman, Fred Winters, is new in his job. Fred tends to run his division full speed ahead without much forethought for the scheduling

Power Distribution in Two Approaches to Performance Review

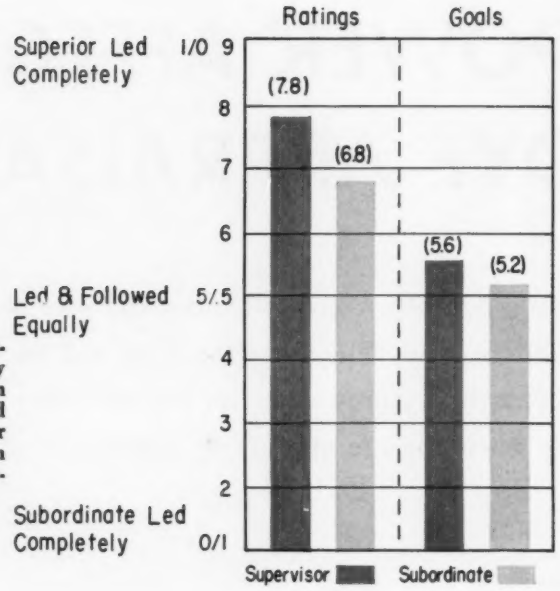


FIGURE 4—Leadership is more equally distributed between the supervisor and subordinate under goals approach than under ratings approach.

needs of or available resources in other divisions. Certain heads in the other divisions have pointed this out to Bob and expressed the feeling that Fred is difficult to work with.

Fred's attitudes also are reflected among his subordinates. For example, his division foremen are hard-hitting, energetic people. They leave little room for supervisors in supporting divisions to take any initiative in contributing to the solutions of common problems.

Bob Hayes is well-adjusted to the organization and sensitive to its demands. His counseling problem is to aid Fred to integrate his efforts into the organization more effectively.

Fred, on the other hand, is particularly proud of his achievements. He is pleased with the caliber of his division foremen and with the cooperation they give him. He has a strong relationship with these men and has achieved substantial economic gains in unit operations. He feels he has flexibility in running his section full speed ahead without committing himself to much more than day-to-day planning.

The Ratings Approach. For the ratings interview Bob Hayes fills in a rating scale concerning Fred's performance. A typical item includes *adaptability* in which Fred's ability to meet new conditions and to execute new assignments is rated on a scale ranging from, "highly versatile, meets new situations readily," through, "adjusts with sufficient ease for good performance," to, "fails to adjust." Others include *job knowledge, punctuality, cooperation, ingenuity, judgment, economy, supervisory skill,* and so on. Thus having rated him, Bob calls Fred in to discuss his strong and weak points and to indicate steps he thinks Fred should take to improve his performance.

The Goals Approach. Under the goals approach, a week in advance Bob and Fred agree on the areas of performance that they want to talk through. They agree to come together with a diagnosis of the situation and with some well defined goals which, if acceptable, will forward the situation. Both have thought about it, and each has come up with some ideas in the areas of planning, interdepartmental relations, development of subordinates, self-improvement, and administrative efficiency. Both have suggestions, but they are by no means identical even though they overlap at some points.

In the area of administrative efficiency, for example, Bob feels Fred ought to free his division foremen and avoid getting so involved in their work details. He also thinks Fred should give more attention to problems at the interdepartment level.

Fred, on the other hand, feels he should strive to further reduce operating costs by another three percent during the next six-month period. During the interview they both work toward establishing mutually acceptable goals from their individual suggestions and toward a time schedule for achieving them.

Half of the supervisors use the ratings performance appraisal method first and the other half use the goals first. Thus in the course of the session each person, whether supervisor or subordinate, has the opportunity of contrasting the two approaches to performance appraisal. After each appraisal is complete, both supervisor and subordinate express their feelings toward the two kinds of interviews.

Distribution of Power. The ratings approach has been characterized as a more or less 1/0 type of interview, with the supervisor telling the subordinate what he needs to do to change. The goals approach is on a more .5/.5 basis with emphasis on attaining a mutually acceptable set of goals through joint participation. Figure 4 demonstrates that the ratings approach is experienced by both the supervisor and the subordinate as being under the control of the supervisor, or close to a 1/0 power distribution. The goals approach results in leadership being more equally distributed, approaching a .5/.5 give-and-take relationship.

What do these results mean? Supervisors are not instructed to act in a 1/0 manner when using the ratings system, nor are they coached to use a .5/.5 approach

in the goals system. Rather the systems themselves contain the power assumptions. In the ratings case, it is extremely difficult to evaluate a subordinate and bring him into a discussion of the ratings without exercising power in a 1/0 direction. Too frequently, what starts out as a 1/0 ratings interview, ends up as a 1/1 fight. By comparison, in the goals system, the inclination is to examine the problems at hand in a give-and-take way without feeling that the supervisor is judging and that the subordinate is being judged.

If for no other reason than the results reported here, personnel heads or line supervisors should be wary of the flowery language describing ratings systems contained in current management textbooks. Textbooks too often tell "how to do it" and remain silent with regard to the dynamics of the relationship hidden in the method.

Teamness. Casting these results against those from the power spectrum experiment presented last month in Part 3 (PETROLEUM REFINER, July, 1960, P. 175) we anticipate that the goals system will arouse a greater sense of teamness than the rating system. The data for evaluating the teamness angle are presented in Figure 5. As you see, teamness is at a minimum, verging on a feeling of separateness between the pair in the ratings interview, whereas both supervisor and subordinate report a relatively high sense of teamness under the goals approach.

These results mean that the ratings method tends to separate people; that is, it pushes them apart and makes them feel individualistic and distinctive rather than as members of a team. The goals approach, by comparison, pulls them together with both searching for solutions to common problems.

If collaboration between supervisor and subordinate is the objective, it is clear that the ratings method does not contribute to it. Rather than producing collaboration, it tends to produce competition and defensiveness. It is equally apparent that the goals system fosters joint thinking and coordination of effort.

Sense of Teamness Between Supervisors and Subordinates

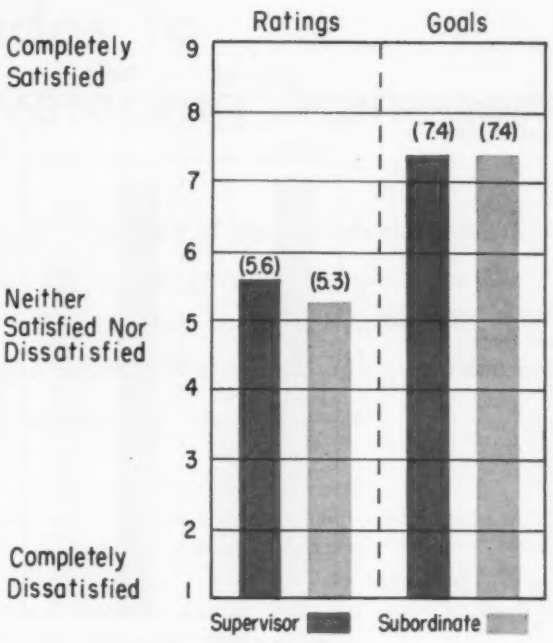


FIGURE 5—Teamness is higher for both supervisors and subordinates under goals approach than under ratings approach.

Satisfaction From Two Approaches to Performance Review

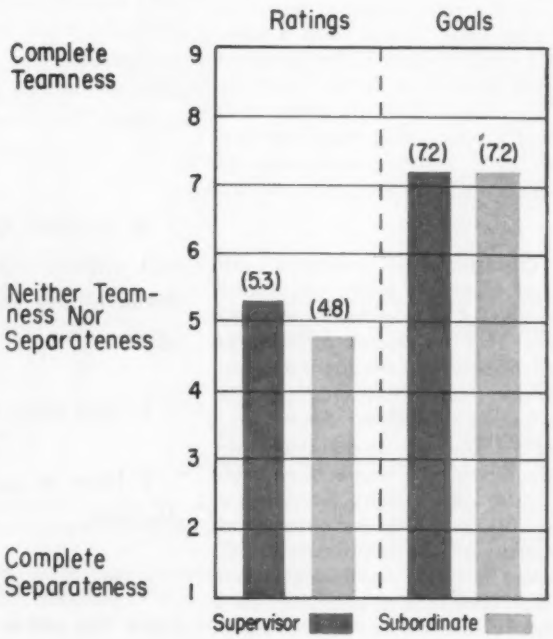


FIGURE 6—Satisfaction is higher for both supervisors subordinates under goals approach than under ratings approach.

Responsibility for Change Felt Under Two Approaches to Performance Review

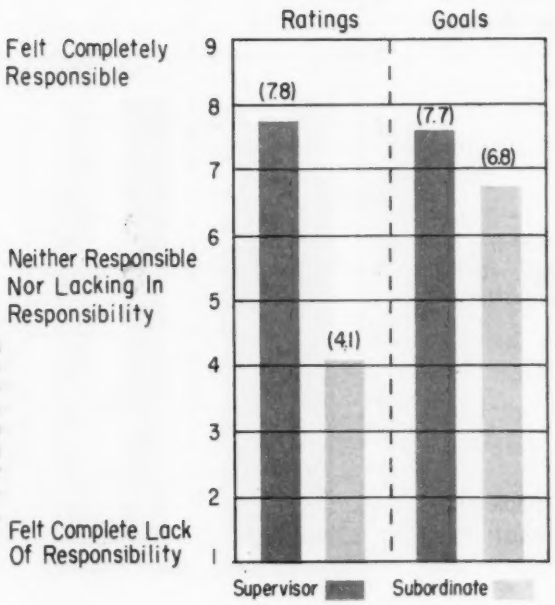


FIGURE 7—Both supervisors and subordinates feel moderately high responsibility for change under goals approach; only the supervisor feels responsible under ratings approach.

Satisfaction. Parallel reactions are apparent in connection with satisfaction as is shown in Figure 6. Both superior and subordinate have a neutral feeling for performance appraisal under the ratings approach—it is neither satisfying nor dissatisfying. In the goals approach, however, the appraisal is very satisfying not only to the supervisor but to the subordinate as well. The most logical generalization then, is that when a supervisor and a subordinate work together in the pursuit of common goals they find satisfaction in the effort expended. Here again, the comparison of results establishes unequivocally that a relationship based on goals accomplishments produces a healthier and more collaborative basis of association than does the classical ratings method.

Responsibility for Change. Also consistent with reactions to the power spectrum, under the ratings approach, are the feelings of responsibility associated with power imbalance. This conclusion is based on results shown in Figure 7. Here we have the ironic situation where the supervisor feels *responsibility* for the subordinate to change *but the subordinate doesn't.*

Here is a paradox of the first class. It says that under the ratings approach the subordinate who is being counseled to change feels little responsibility for doing so while the supervisor who is counseling for change feels a great deal of responsibility for the subordinate to shift his behavior. What could be more frustrating than a situation in which a supervisor feels responsibility for a subordinate with the subordinate feeling reduced responsibility for his own behavior?

On the other hand, both supervisor and subordinate feel a moderately high degree of responsibility for change when the goals approach is used. This finding is particularly significant, for it says that responsibility of the subordinate flows with his sense of power to influence the definition of his own situation. Another way of saying it is that a supervisor cannot dictate responsibility for change. In the final analysis he can only create the conditions under which responsibility is experienced!

Thus, the power spectrum tells the story, When power is shared, as it is in a .5/.5 situation, the basis for control is *mutual* effort, not *directed* effort. Mutuality of interests generates joint responsibility, whether on the battle lines or on the workbench!

Overview. This concrete application of power theory to a specific two-person relationship says that the way a supervisor thinks of himself and utilizes the power available to him in working with subordinates makes a lot of difference. Used one way, he gets one set of results; used another, he gets a different set. Every man has to decide which way to go, but the results here are sufficiently dramatic to a person's thinking if he is using a ratings system of the kind described.

If you want constructive results that lead to satisfaction, teamness and feelings of responsibility in your subordinates, move in the direction of a .5/.5 goal-setting relationship. The data say that you have to make a choice—you can go either way—tell-and-sell or give-and-take. It's an important choice.

In Applied Group Dynamics: Part 5, which will appear next month, you will read about these highly interesting and informative subjects:

1. Why some staff meetings flop.

2. How to go about making a good group decision.

3. The procedures for obtaining agreement from the other members of the group.

10 Guides to Developing Managers

In reading these principles of human development, some will say, "Of course, everybody knows that." But records indicate that these "obvious" principles are more often violated and ignored than observed and honored.

Moorhead Wright, Advanced Management School, General Electric Co.
Crotonville, Ossining, N. Y.

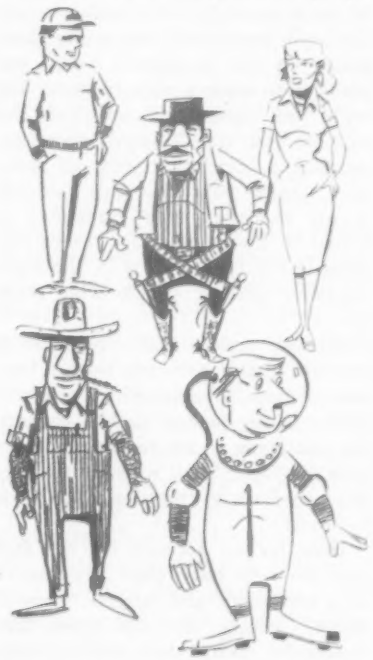
USEFUL GUIDES in the development of "good managers to meet the company's needs" have been set down as a result of a continuing study of personnel problems made since 1951 by General Electric Co. This research checked into "the basic factors involved in the development of people" and is in line with the added emphasis which larger companies particularly are giving personnel problems.

Managing today is a much more complex task than it was. The drastic social revolution, together with rapidly changing technology has made the manager's task much more difficult due to the enormous number of variables which he must consider in planning and decision making.

Additionally, the responsibilities of the business manager have been multiplied. Whereas in the early days of the century his responsibilities were largely economic, there have been added social and moral aspects. And finally, the decentralization and the growth in size of businesses call for a larger number of competent managers who are capable of making their own decisions instead of "doing what they are told."

Much of this work in management development has been a procedural approach based on printed forms and systems and, we must admit, on information which is not too deep or thought-through.

New Project. In October of 1951 General Electric established a research project to "study the basic factors involved in the development of people and recommend a course of action for the company." The initial research was carried out by a team of nine experienced General Electric men, three consulting psychologists, three business school professors, and two top level management consultants.



No person is just like any other person—the individual is unique.

From the research came a mass of data—some of it very sound, strong, and relevant—much of it unimportant. From the good data we have derived ten generalizations which appear to be useful guides in approaching the development process. They cannot be viewed as "eternal verities," because they have not been adequately proven in use. There is, however, enough evidence, both from research and practice, to establish them as useful guides.

The principles are simple and even obvious. In reading them you may be inclined to say, "Of course, of course —everybody knows that." However, study and observation indicates that these "obvious" principles are more often violated and ignored, than observed and honored. Here they are:

1. *The development process is a highly individual matter*

No person is just like any other person—the individual is unique. (This is one of the few things that Albert Einstein, just before he died, said he felt sure of). The individual *is* an individual, and he changes with time. No man today is the same man he was last year.

Thus, it follows that we cannot successfully develop people by means of canned, cut-and-dried, over-stand-

ardized methods. Human development can never be an assembly-line or stamping-machine process. There is no average man to whom you can apply uniformly the same method. What is good for one may not be good for another.

Therefore, all men cannot be developed by some one method, such as rotation, junior boards of directors, or formalized training. Not one but many manager development plans are needed, each tailor-made to fit the strengths and needs of a particular person, and aimed at helping him develop in the best direction.

2. ***Every man's development in business is SELF-development***

The company naturally has an interest in a man's development, and the company can and will help, but it has no obligation, moral or otherwise, to develop the man. The motivation, the desire, the effort, the obligation, and the responsibility for development lie with the man himself.

Development is not something you do to a man. If the approach is manipulative, it is apt to fail or fall short. This is particularly true of the young men entering the business scene. All over the country young men are now coming to business concerns with the attitude: "Here I am. Develop me." This is wrong—for them and for the company. It just does not square with the facts of life, in or out of business.

I don't blame the youngsters for this attitude. I think it is the result of the high demand for, and the low supply of, qualified young men. It is hard to blame the recruiters, either. They go out in competition with thousands of other recruiters, with instructions to recruit a certain number of young men to meet the needs of the business. They have a difficult competitive job, and in the process they may tend to oversell.

So the young men come to us with the feeling that the company is lucky to get them, and that they are here not so much to earn their pay as to be developed. What we ought to say is "We'll give you a real opportunity to grow and plenty of orientation and educational activities. But please do not come in here unless you want to work hard, earn your pay and develop yourself. Don't come to us unless you recognize that the responsibility for your development is primarily yours."

The obligations and responsibilities for development rest with the individual. However much and however often it may be obscured, this principle is finally unavoidable.

3. ***The development of people cannot be based upon any set of ideal or specific personality characteristics or traits***

Many of us have been trying to do it that way for the past 20 years, but it doesn't work very well. Why not? The following bit of personal experience gives us an indication. When I started to work on the research team, they asked me some pretty sharp questions. They said, "You are going to develop managers for the General Electric company?"

I said, "I am going to try to help managers to develop themselves."

They said, "The main thing is to have a good manager, isn't it?" I agreed.

They said, "What is a good manager? What are the personality characteristics a man should have in order to be a good manager?"

Well, I went off and did some thinking. And the more I thought, the tougher it got. Suppose you could arrive at the personality characteristics of the ideal manager. Would you then set up a prototype ideal manager who had only these ideal personality characteristics and no others? Would you proceed to raise a race of supermen with just these characteristics? But suppose you actually could somehow produce a breed that were all alike, and suppose you had this uniform crowd managing the company; it would be a sour omen for the future, because GE's strength is in the individuality of the people who compose it.

Another serious difficulty arises if you are going to work toward any sort of ideal "personality pattern:" What, in the face of such a pattern, are you going to say to the managers now in place? Shall we say that they must conform to this ideal pattern or be fired?

How do we account for the fact that we now have good managers who are tough and rugged "personalities," others who are quiet and thoughtful men, others who are aggressive-salesmen type, and others just as widely assorted—all good managers? The truth is that there just isn't any standard pattern of personality traits that make a good manager.

A Long List. At a certain stage of the exploration of the "personality trait" approach, I asked one of the men to do a little library research and find out what the outstanding authorities on this subject say, what they indicate as the necessary and important personality characteristics that make a good manager. At the end of five weeks he turned up with between three and four hundred "necessary" and "important" characteristics—an amazing hodgepodge of contradictions, generalities, and vagueness.

The conclusion is that "personality traits" are not something we can base our development approach on. We cannot define them; we cannot measure them, and only with the greatest difficulty and with a very high degree of unpredictability can we change them. There are only a few really effective ways to change personality traits. One is psychoanalysis; another is religious conversion. Obviously these are resources we cannot introduce into our operation.

In my judgment—and I have tried it many times—rating sheets based upon personality traits have generally failed in actual application. Time and again men who rate poorly turn out to be good managers, and vice versa. We have to take men as they are, with the traits that they have, and try to bring about their development from that basis.

So the focus is upon the work rather than the individual personality. Work can be seen—identified—analyzed—measured. Work is specific, tangible, get-at-able. And work is basic. In the field of management particularly, there is an important checkpoint in evaluating a man's work, because there is a single common denominator among all managerial jobs. Whether he is in charge of a research laboratory, a dress shop, a cafeteria, or whatever, the manager must get results *through the efforts of other people*. This is the common element. The manager's assignment is always too big for one man, so he has other people working with him to get it done.

Three Points. There are three things that a manager must know:

1. The product or service,

2. The specialized work of the operation he is managing,

3. The common denominator of

getting results through other people.

The third factor is the particular work of the manager. With a reasonable amount of break-in, he can often learn the first two, but his ability in the common denominator is what really qualifies him.

Therefore, in one's search for managerial talent, one should seek not men with certain "personality traits," but men who indicate or demonstrate an ability to get results through others. Further, education or development activities should be directed at teaching or helping to develop this ability. Managing work can be identified as a separate and distinct kind of work which is becoming more scientific and professional, and which can be taught and learned.

While there is no implication here that managers are universally interchangeable, a man who manages one operation well often will manage another operation well, because he manages the work of others in a perceptive, skilled way. He may not know all the aspects of the business intimately for quite a while, but he recognizes the people who do know and puts them in the right positions where they will make the right decisions.

Of course, a man's personality should not be ignored. It may turn out in some cases that the basic problem lies in this area of personality; but that is something which the man has to work on himself. The company tries to understand, but it does not get involved. It stays in the realm of work with special interest in indicated or demonstrated capabilities and drives, which indicate the best future direction for the man.

4. *A man's development is 90 percent the result of his experience in his day-to-day work*

Researching this subject, a group of outside interviewers talked to 300 GE managers, men who had developed to the point where they had managerial responsibilities.

The interviewers asked these men: "What do you consider the thing that was most important in your development? What did the company do to help or hinder your development?" These, remember, were outside interviewers; the sessions lasted 2½ to 3 hours; and the anonymity of the managers was protected so that they felt free to say exactly what they pleased.

And 90 percent of them said, "I got my greatest development when I was working for so-and-so in such-and-such a place." Only 10 percent attributed major developmental importance to educational background, special courses, rotation, etc. The outstanding factors in the development of these managers were the manner in which the man was managed in his daily work, the climate in which he worked, and his relationships, particularly with his immediate manager.

Correlated at GE. This same point is proved by another quite intensive (and expensive) piece of research. The records of 890 GE managers were punched on IBM cards and run off for correlations. The objective was to find out if any significant number of managers had arrived at their positions due to any one significant factor among the 45 factors studied.

For example, had they progressed because they had held a lot of different jobs, that is, because of rotation? The answer was no. Present GE managers had held assignments in an average of 1.1 functions since coming with the company. We looked for significant correlations with education, functional background, and many other things but found none.

Here was further proof that when the first group gave only a 10 percent weight to civic activities, outside courses, rotation, etc., they were probably rating them about right. Of course, these things are important, but direct daily experience is so much *more* important that there is just no doubt about where the major attention should be directed. Every man has experience in his day-to-day work that tends to accelerate or retard his development. He is daily reacting to the climate in which he works and to his relationship with his immediate manager. And these appear to be the most important factors in the development process.

5. *Opportunity for development must be universal*

Everybody must be given opportunity to develop—not just a small group, not even a large group, but everybody. There can be no dividing lines between "promising men" who will be developed and "unpromising men" who will be ignored. There can be no separation of the sheep from the goats. Opportunity must be available for everyone who is motivated to accept it and go to work on it.

Many development programs today have been based on the idea of selecting the "high potential men," picking ten out of a thousand and saying, "These are the boys we will develop." So these are anointed and all attention is put on them, and the others are just "not on the development program."

During the process of researching the merits and demerits of this very common practice we dug out one of the "promising young men" lists of ten years ago. There were 143 names on it. The question arose: "Where are these boys today?" The researchers proceeded to look around and find out. Only 37 percent of them had achieved the success predicted. It shows how wrong these arbitrary "crown prince" theories can be.

Lesson from Lincoln. There are historic warnings against the promising young man type of selection for development. Abraham Lincoln, for example, was a consistent failure in his early life; he failed in the Legislature, failed in the Senate, and went through bankruptcy; he certainly wouldn't have been on anybody's "promising" list.

Thus it follows, as a basic principle, that everybody must be given a chance, and that no artificial distinctions can be made during the development process. Obviously the man of limited ability is not presented with the same opportunity that is given to one of your real up-and-coming bright young men, but each of them should get the appropriate opportunity. The lesser man should have appropriate opportunity in the beginning and subsequent opportunity as earned. The brighter man will earn them faster and bigger than the dull man. But this is a matter of degree, not of black and white. Nobody should be left out —provide room for happy surprises, dark horses, poor starters and strong finishers.

This is a considerably different

approach from that of the past. It is the hard way in the beginning but the best way in the end.

6. *Primary emphasis must be on development in the present assignment, rather than emphasis on a promotional ladder*

We do not suggest you ignore promotion as a development factor. But if undue stress is laid upon the promotional ladder, everyone begins to feel that he is in his present job only temporarily; that he is on his way up; that he must devote most of his attention to looking ahead and not to getting his present work done.

This means that the company's work doesn't get done, and you couldn't have a worse result from a development activity. Furthermore, when main emphasis is on promotion, the inevitable outcome is a lot of expectations that cannot be fulfilled and a lot of promises that cannot be kept. The final result is apt to be unnecessary disappointment all around.

Research to date points to saying something like this: "Boys, keep concentrating on doing today's job particularly well. This is the base from which all advancement is made." It also has the great advantage for the man's incumbent manager in that it helps get the work done. Thus, while a manager is helping people develop, he is making his own job easier, not more difficult.

Now, you may say, "If the man who is working on development concentrates solely on his present job, is he not failing to broaden himself for bigger responsibility? Won't he be unable to take the bigger assignments when they come?"

The answer is that he should concentrate not solely but primarily on the present job. While he is thus concentrating he is encouraged and helped in every way that will broaden him and make him capable of taking on a bigger job in the future. At the same time his advancement is directly related to performance.

This eliminates the "replacement table" kind of set-up in which everybody is on the move all the time, or thinks he should be on the move all the time, and in which a lot of people are always frustrated and mad and dissatisfied. Broadening-for-the-future should be an additional factor; the main objective is doing today's work better.

7. *Managing is a separate and distinct kind of work which is emerging as another profession*

This must be recognized in planning a man's development and in appointing people to managerial positions. We must, therefore, get the best possible answer to the question: "Does this man have the capabilities and drives to enter the profession of managing, or should he continue to progress in his present field?"

Take for example an engineer; his profession is engineering. If he is made a manager his profession is changed from engineering to managing. But it does not necessarily follow that a good engineer will make a good manager. He may or may not be well suited to the profession of managing. It is of pivotal importance to judge accurately in advance whether he is or not.

We must estimate, from sensitive observation of his work, whether he has the desires and capabilities that fit a man for the profession of managing. This is a safeguard against the very common mistake of saying, "We need a manager of engineering. We'll look around and pick our best engineer and put him in this spot." If we followed this line of reasoning in, say, baseball, Ted Williams would be manager of the Red Sox.

Often, in the past, the best engineer was made engineering manager—and failed. The star individual salesman was made sales manager—and failed. Many times the outstanding individual performer is made a manager, and we lose the good individual performance and get a mediocre manager; all because of failure to realize that managing, in itself, is emerging as a profession, with its own particular professional requirements.

In planning a man's development, the first question is: "Is this man in the right kind of work? Is he headed in the right direction for him?" It is really a difficult decision to make, but if man and manager look at it from this point of view, the chances of making good choices are considerably improved.

Manager or Individual Contributor? General Electric policy makes this important statement of intent: "In making the choice between manager and individual contributor positions for a man, remember that the General Electric Co. owes much of its success to the fine work of individual contributors, and rewards for such work can be and should be equal to those for managerial work."

So in GE it is the intent, and to a considerable degree it is a fact, that individual contributors have an open path of progress with reward based on contribution rather than on a position in the hierarchy. However, there is a problem in implementing this intent, arising out of a long tradition of prestige for the management function. Managers often have been able to command greater rewards, bigger offices, etc. Accurate decisions in this area will not be possible until ways can be figured out to identify the work of the individual contributor and to measure the value of his contribution.

There is also a long history and a large background on what to pay managers. There is no comparable frame of reference for what an individual contributor should be paid. But there is some progress in the direction of real fairness and full encouragement of the individual contributor as well as the manager.

8. *Decentralization of decision-making is a prime instrument of development*

Decision-making muscle is developed only by making decisions. There is much literature on the subject of decision-making, and of course there is much value in studying it, but no one can really develop judgment and learn how to make good decisions except by actually making decisions. As in golf, bridge, and any other skill, learning is done not only with the head, but with the muscles and the intestines, and this kind of learning comes primarily from doing.

Now, decision-making opportunities for men working on their development are not available if most of the decision-making power is concentrated among a few of the top brass. Organization structure, therefore, is an important and inherent part of the development process, because it opens or limits the field for individual decision-learning.

One big company discovered that many of their best executives came from small isolated plants. They won-

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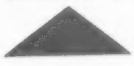

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dered why. They investigated and found that the development of these men had been greatly stimulated by the opportunity, indeed, the necessity for making decisions as they came up.

Organization decentralization puts many men in a position to decide independently, who otherwise would be running upstairs to get their proposals checked and having decisions handed down to them from above. Then if anything went wrong they would say: "You told me to do it."

9. *The incumbent line manager at all levels is responsible for the development of people who work under his direction*

This principle is somewhat of a departure from previous practice, so the reasons for it need particularly to be understood.

Many managers say: "My main job is to make the product and bring in the profits. I'll let my personnel man do the developing work, or I'll send the boy to a school and let them develop him."

It is not possible for a manager to delegate the development process. He can delegate the legwork and some of the educational activities, but primarily he has to carry the responsibility. Part of his job is helping the people who report to him to develop themselves. He must watch the climate that exists; he must make development plans for and with his men; he must originate opportunities and work situations which will challenge and develop these men.

One Danger. Very often, in cases where development is a separate and special program, the results can be detrimental instead of constructive. A man may be appraised by someone other than his own manager; he may take special company courses and engage in other developmental activities and acquire considerable information and inspiration. This may lead him to see some of the shortcomings and faults in the organization and he will return to the job full of enthusiasm for improving the whole operation.

In many cases this is good, but in many others he finds an apathetic or even hostile reception to his ideas. If his manager is not interested in his development, and is on the defensive (as they often are), a frustration and resentment will be built up in the individual, which may lead to retrogression instead of development.

There is considerable evidence that it is unwise even to have a specialist in development. The danger here is that the line managers will use the presence of the specialist as a reason for shirking their own work in the development area. "George is the management development specialist—that is what he's paid for. Let him do the development; I've got my bucket full running this shop."

Many managers feel they need an expert to help with this difficult responsibility. This can be beneficial provided the manager development specialist does not try to make a big job for himself to get a sense of power, and further that the line managers use him *only* as a source of information and guidance.

Actually, development work can be one of the most satisfying parts of a manager's job. And, rather than hindering or interrupting, it helps him get his work done when he operates on an integrated, reciprocal basis rather than on a basis of command, giving orders and holding the whip. The man who feels he is developing through his work performs voluntarily at a much higher level of effectiveness. This is motivation in the true sense.

10. *Moral and spiritual values are basic in the development process*

Those who place too much emphasis on science, mathematics and accuracy, may overlook the obligations that stem from this key principle. As a matter of fact, not only American business but American history is at a crossroads in this connection. For a long time now we have been growing more and more materialistic, making more and more progress along lines of material science, making great discoveries about the atom and electronics and chemistry and many other things. This multiplying knowledge of the physical world gives man enormous power, and with it, enormous obligation to be right.

Throughout history, the human being has advanced very little or not at all, while the scientific and physical things he has in his hands have grown out of all proportion. It is a terrible commonplace to observe that man now has the power to destroy himself and his world. We must find the way to greater wisdom in handling our present power for good or evil, or we will leave a terrible mess for our children.

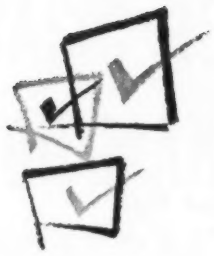
It seems absolutely necessary that we reach out and try to find some wisdom greater than our own. We have to reach out and up for the great help we need in making decisions with regard to these physical things and to the people involved in them. The decisions of American business managers are going to have a great effect upon the course of the world. This is a business-oriented society. Businesmen have real leadership in this country—and this country has real leadership in the world.

In Conclusion. These then, are ten thoughts which may serve as guides for those interested in developing people. They are oversimplified, and are only a few facets of an extremely complex problem. As a matter of fact, I would say one of our principal findings was that we need much more research before we can begin to know even a part of the many factors involved.

There are great gaps in our knowledge which may not be filled for generations. However, we hope that in time we will have sufficient knowledge about the development of people to enable all managers to do, more effectively, this development task which is both their obligation and opportunity. # #

About the Author

Mr. Moorhead Wright has been with General Electric Co. since he received his electrical engineering degree from Cornell University in 1927. His experience includes both engineering and sales activities at headquarters and in the field. Most recently, after serving as manager of employe relations, Hotpoint, Inc., Chicago, he was named assistant to the president of that company. As such, he organized a comprehensive program of organization and management development. After three years as a lecturer and leader in GE's Advanced Management Course, he attained his present position as manager-operations of the company's Management Research and Development Institute, Crotonville, Ossining, N. Y.



Test Yourself on Labor Relations

No. 1–Assigning Overtime

Because of an oversight, Jack Calle was skipped on an overtime assignment. The company had a policy which provided that overtime would be "distributed equitably." Calle went to his foreman.

"Bill," he said. "It was my turn to work overtime last night. You skipped me and I lost three and one-half hours pay."

"I'm sorry, Jack," the foreman replied. "I slipped up. I'll make it up to you. First overtime we get in this department will be yours. Okay?"

"No, it's not okay. I want to get paid for the overtime I didn't work. I'm entitled to it."

The issue went to arbitration and the company claimed that it didn't have to pay. Its only obligation was giving Calle a chance to make up the loss by working. "Overtime pay is for working. It can't be used to penalize an employer for an honest mistake," the company concluded.

Test Yourself:

Was the company Right ☐ Wrong ☐

No. 2–Can Employe Force Arbitration?

Jack Kitnor had a beef against his supervisor and went to his union. "I want you to file a grievance," he demanded.

"Okay, Jack. We will. We don't think you have much chance of winning, but we'll try."

The grievance went up to step 3 and management backed up its supervisor.

Kitnor insisted that the union proceed to arbitration. "We won't do it, Jack. The company is right and we'd only get licked at arbitration."

"Listen," Jack retorted. "I pay my dues and you must go to arbitration. That's your job. If you don't, I'll go to court and force the company to arbitrate with me."

Test Yourself:

Was Jack Right ☐ Wrong ☐

No. 3–Men Want Call-In Pay

One morning, about 7 o'clock, a valve broke. The maintenance foreman spied three of his morning-shift crew chatting near the time clock. "Come on in, men," he said. "I've got a job for you right away."

"We're not due for half an hour yet. We came in early," was the reply.

"That's okay. Clock in now and I'll pay you overtime. A valve has gone out of commission," the foreman answered.

The men clocked in and went to work. At the end of the week they received ¾ hour pay. (This was time-and-a-half for the ½ hour they clocked in early.) But the men claimed 4 hours call-in pay. They argued:

1. We were called in to handle an emergency. We're entitled to the 4-hour guarantee in the contract.

The company refused. Its position was:

1. These men were not called in outside their regular hours. They were in the plant and were asked to work ½ hour overtime before their shift started. This doesn't entitle them to call-in pay.
2. The purpose of call-in pay is to compensate employes for inconvenience or hardship if they are called in to work when they are away from the plant.
3. These men are entitled to overtime and that's what we paid them.

Test Yourself:

Was the company Right ☐ Wrong ☐

Answers on page 235

New Books...

Right to Manage

"Management's Right to Manage" points out that American management, faced with today's ever-spiraling costs and increasingly strenuous competition, is being forced to re-examine the serious limitations placed upon its right to manage by union demands, the collective bargaining process, labor arbitration awards, and court decisions. This book explains what management rights are and why they are important. It shows how they can be eroded away or greatly circumscribed by thoughtlessness or inexperience on the part of management itself. It cites many instances of seemingly harmless union proposals for changes in collective bargaining agreements which turn out, upon close examination, to strike at the very heart of management's right to manage. It traces the evolution of the present concept of management rights under the impact of successive arbitration decisions, and concludes that management has largely itself to blame for such losses of its rights as it has sustained.

A large part of the book is devoted to a topic-by-topic discussion of a score or more of management rights which have been the subject of arbitration. As it passes each topic in review, it spells out the factors of concern to management, explains the exact nature of the circumstances which gave rise to the dispute in question, summarizes the pertinent arbitration decisions, and offers cautions on the pitfalls management should watch for.

Parts include: What Rights Are We Talking About?, Why Management Rights Are Important, What Has Happened to Management, What Has Happened in Specific Areas, How Management Rights Are Lost, An Approach Toward Preservation of Management Rights.

(Torrence, G. W., *Management's Right to Manage,* BNA, Inc., 1231 24th St., N.W., Washington 7, D.C., 109 pages, $12.50.)

Writing in Industry

"Writing in Industry" contains selected papers from the proceedings of the Conference on Writing and Publication in Industry, 1959, sponsored by the Polytechnic Institute of Brooklyn. Among the seven chapters, two have especial value for the industrial employe: "Writing for Publication; Why and How?" and "Production and Design Problems in Engineering Publications."

(Mandel, Siegfried, *Writing in Industry, Volume 1,* Polytechnic Press of the Polytechnic Institute of Brooklyn, distributed by Plenum Press, Inc., 227 West 17th St., New York 11, 121 pages, $2.75.)

Polymers and Resins

"Polymers and Resins" covers the theory, chemistry, properties, manufacture, fabrication, and application of all commercial polymers and resins. Up-to-date accurate treatment is given fibers and elastomers as well as plastics. Emphasizing commercially useful polymers, it classifies substances by chemical type and similarity rather than by physical end use and avoids the grouping of chemically unrelated substances which happen to be useful in a particular field (elastomers, for example).

A detailed account of organic chemistry involved in manufacturing the materials needed for polymer production is given. The chapters on fabrication and applications are especially valuable to engineers. A chapter on physico-chemical behavior also delves into the relationship between molecular configuration and the differing properties of various polymers.

The volume has many line drawings and photographs, which may be useful in the plant, laboratory or classroom.

(Golding, Brage, *Polymers and Resins,* D. Van Nostrand Co., Inc., For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, 744 pages, $15.)

Safety Talks for Foremen

"Five-Minute Safety Talks for Foremen," the 10th in a general industrial safety series, is divided into sections on motivation, machines and tools, materials, movement and managing men. A collection of 52 safety talks written by Kemper Insurance Co.'s superintendent of engineers, the book is based on material gathered by the author in more than 20 years in safety engineering. Industrial companies will want to keep the book as background material for safety talks and articles.

(Moore, R. L., *Five-Minute Safety Talks for Foremen,* National Safety Council, 425 North Michigan Ave., Chicago 11, Ill., 112 pages, $2.25.)

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Energy and Man

"Energy and Man—A Symposium" contains five distinguished authorities on the production, use, and importance of energy in civilization. They have collaborated to produce a symposium of decided significance.

The contents of the book are centered on five papers, entitled *Energy in the History of Western Man, The Petroleum Revolution, Energy Patterns of the Future, Low Cost and Abundant Energy,* and *Energy and Public Affairs.* The papers were originally presented as addresses at a gathering of over 300 government officials, business executives, scientists, historians, and economists, who met at Columbia University, Nov. 4, 1959, for a symposium co-sponsored by Columbia's Graduate School of Business and the American Petroleum Institute as a part of its centennial activities.

Together with the discussions that follow each talk, these addresses form a stimulating and thought-provoking volume for the executive and scholar alike.

(Nevins, A., Dunlop, R. G., Teller, E., Mason, E. S., Hoover, Jr., H., *Energy and Man—A Symposium,* Appleton-Century-Crofts, Inc., 35 West 32 St., New York, 113 pages, $3.75.)

Industry Housekeeping

"Housekeeping in the Chemical Industry" explains how careful initial planning of any aspect of chemical manufacturing will do much to accomplish safe results. It covers the responsibility for good industrial "housekeeping" and the benefits thus derived. The booklet describes in detail how this desirable practice can be established and maintained.

(MCA, *Housekeeping in the Chemical Industry (SD-2),* Manufacturing Chemists Association, 1825 Connecticut Ave., N. W., Washington 9, D. C., 4 pages, 20 cents.)

Chemical Periodicity

"Chemical Periodicity" discusses the physical nature of the elements, the binary chemistry of oxygen, hydrogen, nitrogen, sulphur, fluorine, bromine, iodine and the properties of simple alkyl and aryl derivatives for the elements. It has a collection of more than 60 periodic charts which show the general trends and relationships among all the elements, with respect to the physical properties of the elements or of the compounds with the different nonmetals.

(Sanderson, R. T., *Chemical Periodicity,* Reinhold Publishing Corp., 430 Park Ave., New York 22, 320 pages, $11.75.)

BASIC REASONS FOR MAKING GENERAL CHEMICAL YOUR "HQ" FOR HF

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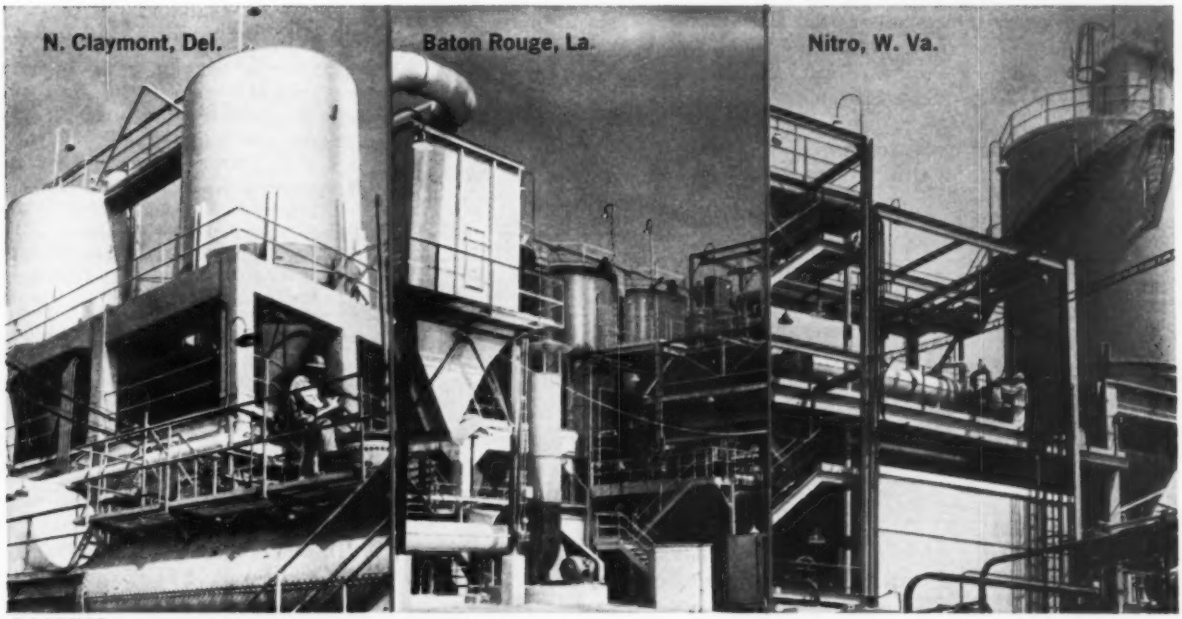

3 PLANTS. General Chemical produces anhydrous and aqueous hydrofluoric acid at the following three locations: North Claymont, Delaware; Nitro, West Virginia; and Baton Rouge, Louisiana.

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Hydrogen Recycle Ratio Solved by Slide Calculator

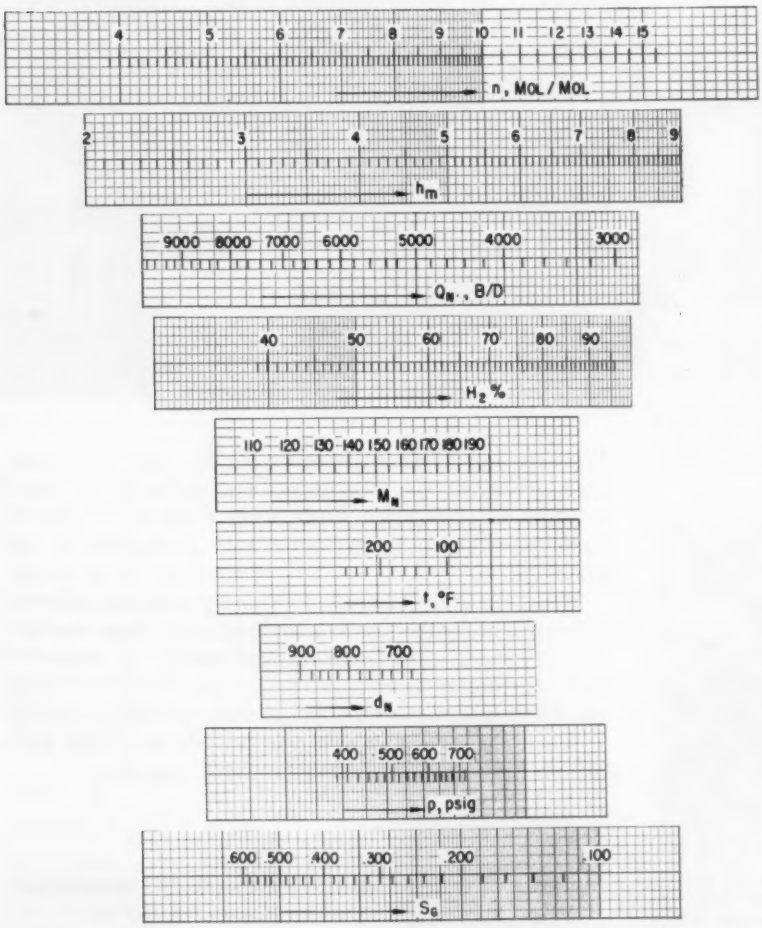
For frequently repeated calculations, alignment charts are generally used. However, for four or more variables, alignment charts are difficult to handle. For cases such as the calculation of the hydrogen recycle ratio in a catalytic reformer, a calculator based on the slide-rule principle can be used. It speeds up calculations and makes them foolproof.

The calculation of the hydrogen recycle ratio, which is generally made each second hour is based on the equation:

$$n = 1.075 \times 10^{-4} \times H_2 \times \frac{M_N}{d_N} \times \frac{Q_G}{Q_N} \quad (1)$$

where

n = recycle ratio, Mol/Mol
H_2 = Mol percent H_2 in recycle gas
M_N = molecular weight of naphtha charge
d_N = specific gravity of naphtha charge
Q_N = flow of naphtha charge, bpd
Q_G = flow of recycle gas, SCFH



As the temperature, pressure and specific gravity of the recycle gas varies with conditions, Q_G must be calculated first from the equation

$$Q_G = k \frac{\sqrt{p + 14.7} \times h_m}{(460 + t)\sqrt{S_G}} \quad (2)$$

where

k = constant, depending on pipe and orifice size and on meter range
p = pressure of recycle gas, psig
t = temperature of recycle gas, °F
h_m = reading on the square root chart
S_G = specific gravity of recycle gas at 60° F (air = 1)

Combining equations (1) and (2) gives the following equation:

$$n = 1.075 \times 10^{-4} \times k \times \frac{\sqrt{p + 14.7} \times h_m}{(460 + t) \times \sqrt{S_G}} \times H_2 \times \frac{M_N}{d_N \times Q_N} \quad (3)$$

To solve equation (3), an alignment chart with 15 lines would be required. The ratio $\frac{M_N}{d_N}$ is often nearly constant and then can be included in k but even in this case the equation still contains six variables.

To prepare a "slide calculator" for the above equation, two logarithmic scales with a modulus ratio of 1:2 must be used. In the figure, logarithmic paper with moduli of 12·5 and 25 cm were used to prepare the slides for the variables in the following way:

n, H_2, M_N and h_m: values are marked on paper with 25 cm modulus (strips 1, 4, 5 and 2)

Q_N, d_N: on paper with 25 cm modulus the values of $\frac{1}{Q_N}$ and $\frac{1}{d_N}$ are marked but the respective

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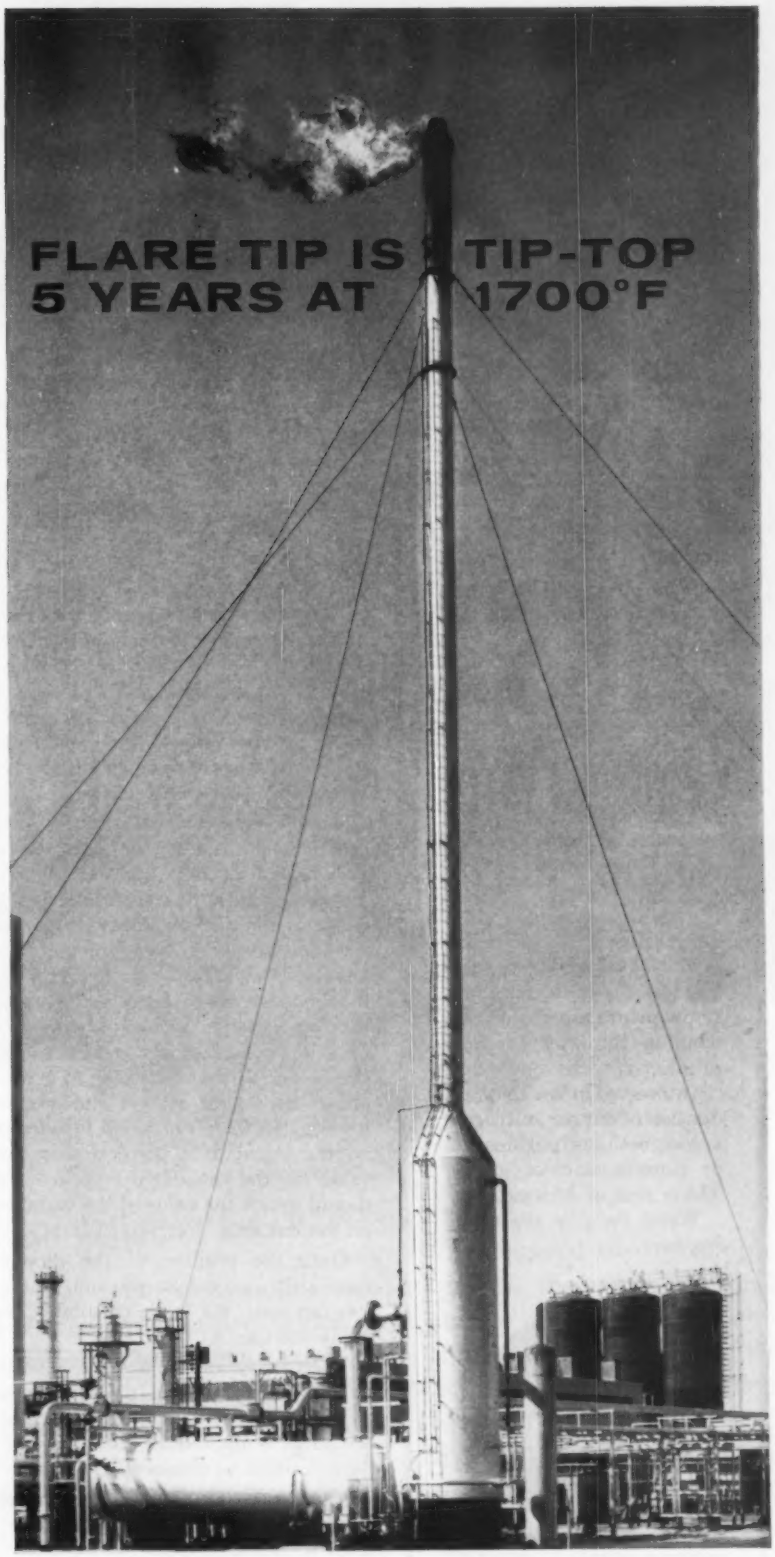

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How To Do It . . .

values of Q_N and d_N indicated (strips 3 and 7)

p: on the 12·5 cm modulus paper, the values of p + 14·7 are marked and the corresponding p values shown (strip 7)

t: on the paper with 25 cm modulus, the values $\frac{1}{460 + t}$ are marked showing the values for t (strip 6)

S_G: the values of $\frac{1}{S_G}$ are marked on paper with 12·5 cm modulus and values of S_G shown (strip 9)

The strips are cut to a length to include the normally found values for the variables. For easier handling they should not be cut shorter than about two inches and they can be protected with a plastic cover. Any desk can be used for the calculation but it is handier to have a piece of board with a raised lip along one edge.

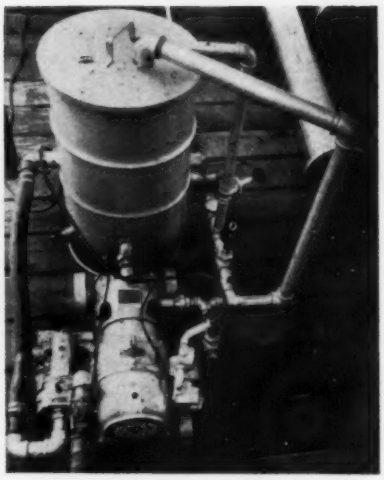
To get the calculator ready for use, one recycle ratio for a given set of variables must be calculated. Then, any one of the strips (except strip n) is put at the marked starting point or into the corner of the groove. The next strip is placed on this strip so that its edge fits to the given value of the first variable. The other strips are lined up similarly, any sequence can be chosen. When all are led in a row along the longer arm of the groove the strip for the result (strip 1) is fixed on the board in a position that the value for the calculated recycle ratio should match the value of the variable on the last strip.

Once the position of the recycle ratio strip is fixed in relation to the starting point the "slide calculator" is ready for use.

The calculation for any set of variables is carried out in the same way as the first one, again the sequence of the strips is indifferent. It takes only some seconds to obtain the result.

The "slide calculator" can be used for any equation which can be calculated with a slide rule.

This item was submitted by A. L. Salusinszky, Standard Vacuum Refining Co., Williamstown, Victoria, Australia.



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The suction from the vessel to be cleaned comes in at the lower right and is discharged through the jet into the drum at the upper right along with the water which is constantly circulated through the jet.

The top view shows how the auxiliary pump is connected using sectional V-belts on a pulley attached between the motor and the pump. The intake to this pump connects to the drum half way up and maintains this level at all times, regardless of the rate of entry from the vessel being cleaned. The discharge to the slop tank is shown in the photo at the lower lefthand corner.

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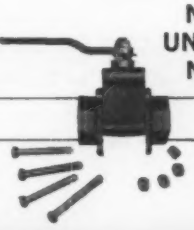

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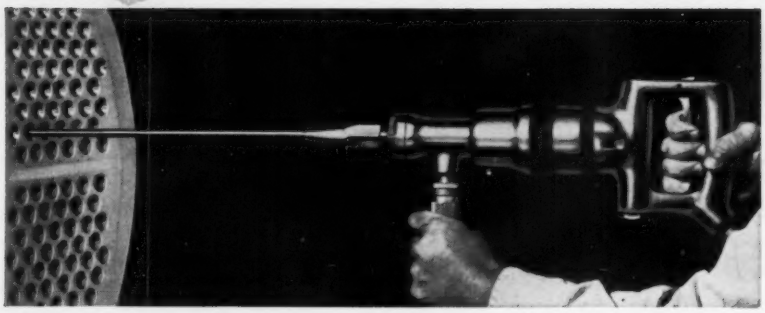

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A piece of scrap railroad rail can be cut off with a point on one end and a square on the other and mounted on a stand to make a shop anvil. The welder simply burns a section about two feet long and cuts back under the rail about six inches on the square end and about 10 inches on the pointed end. He then burns holes to anchor the anvil to a piece of log standing on end. A hole is cut in the side to attach an overhead crane hook for easy transportation.

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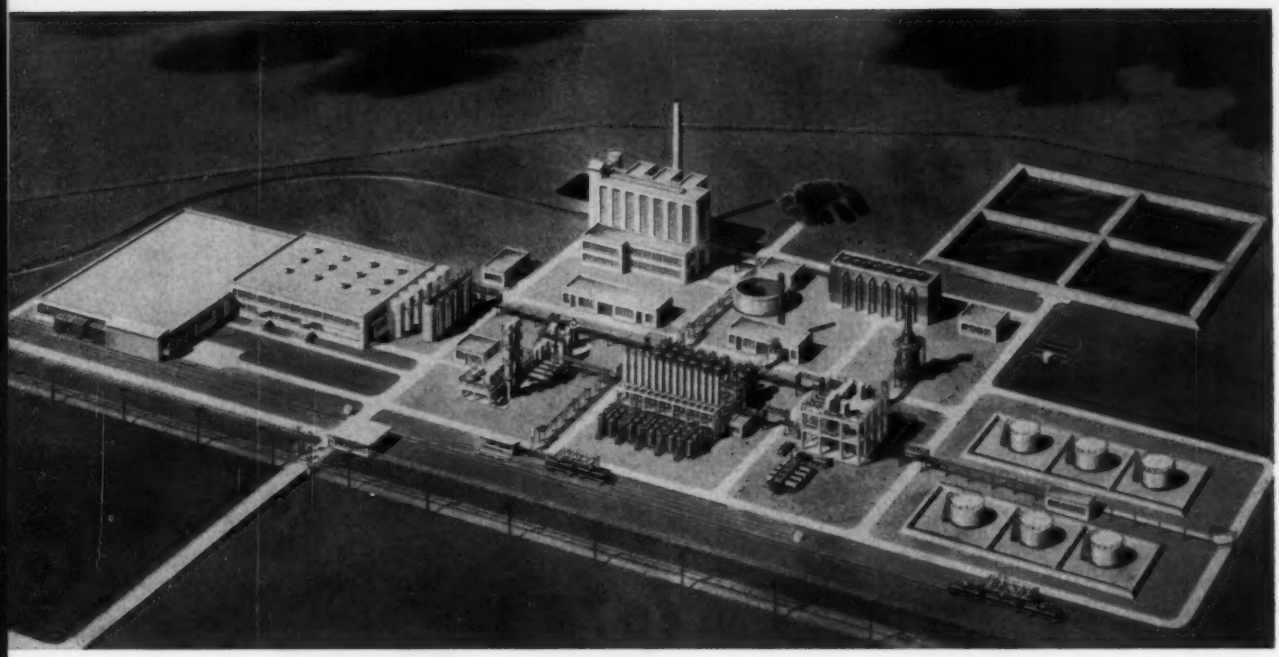
Who's Building...



Drawing shows rubber plant to be located near Bareilly, Uttar Pradesh

India's First Rubber Plant Planned

New $30-million project will be designed to produce a capacity of 20,000 tons. Units to produce butadiene and styrene also included

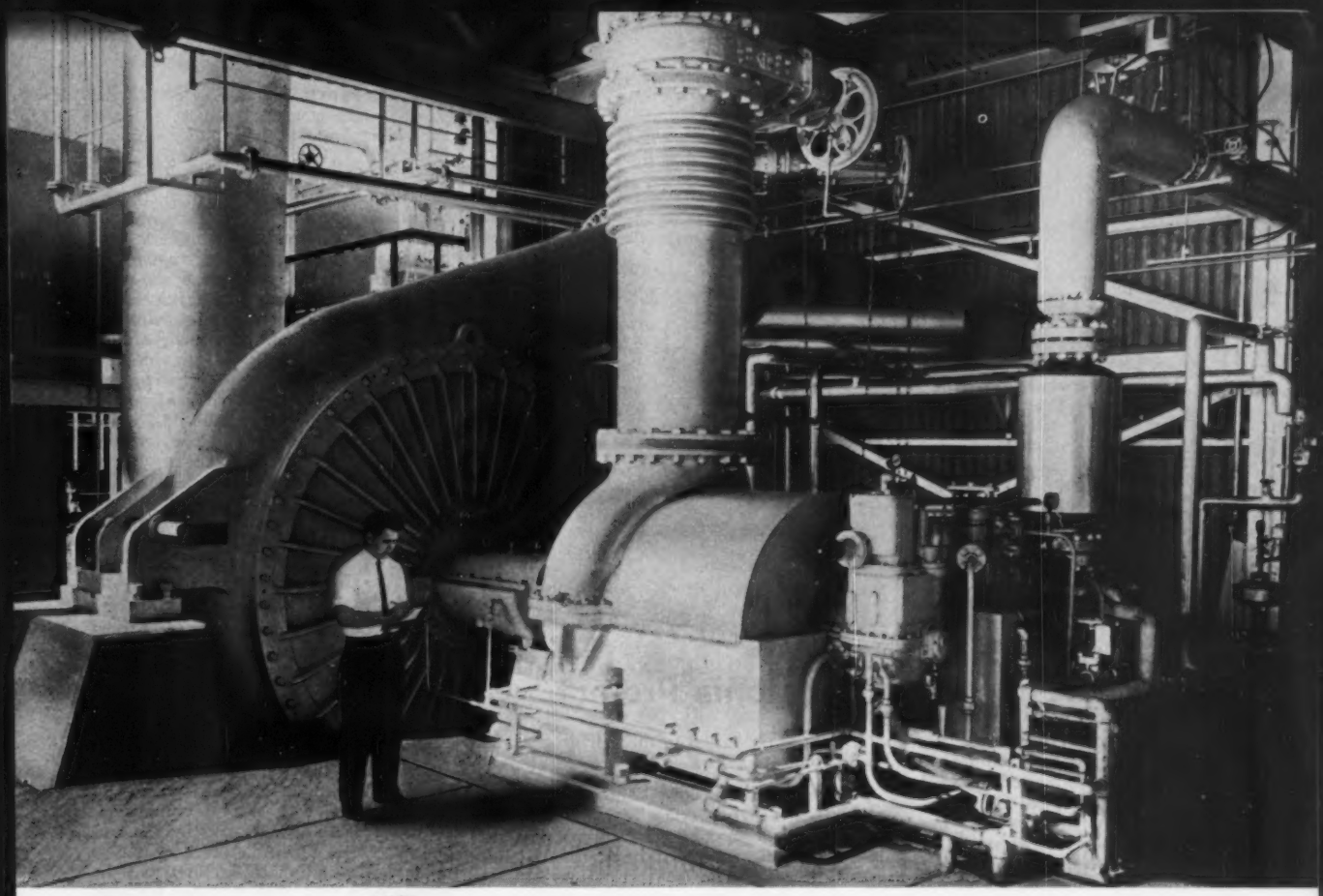
India's first synthetic rubber manufacturing plant near Bareilly, Uttar Pradesh, is currently in the planning stage. The Lummus Co. will build the plant, which is a $30-million project. Lummus will direct work for Synthetics and Chemicals Ltd., a company formed by Firestone Tire & Rubber Co. and Kilechand Devchand and Co., Private, Ltd., a Bombay banking and industrial firm. Construction will commence within several months.

Units to produce butadiene and styrene as well as a copolymer plant to manufacture synthetic rubber are included in the project. Lummus will also construct all the plant utilities and offsite facilities.

The plant will be designed for an initial annual capacity of 20,000 tons, and will be "rapid expandable" to 30,000 tons. Technical divisions of Firestone Tire & Rubber will furnish the basic engineering and know-how for the butadiene, styrene and copolymer units.

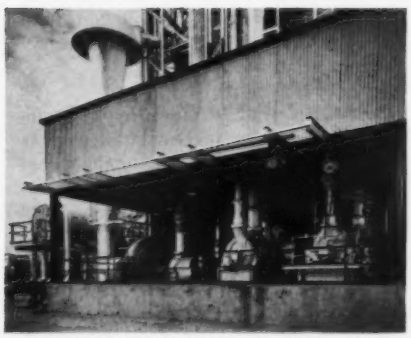
The plant site near Bareilly, is in the heart of the sugar cane and alcohol producing area, which provides a source for alcohol for use in the manufacture of the butadiene. The India-produced synthetic rubber will meet standard world-wide industry specifications, James F. Thornton, president of Lummus, stated.

A $8,250,000 loan from the Export-Import Bank of Washington will assist in financing the construction. This is reportedly the largest foreign currency loan in the bank's history. The remainder of the financing will come from private banks in the United States, United Kingdom and India. Operation of the synthetic rubber plant is expected to save India about $10 million in foreign exchange annually.



BIG SINGLE-STAGE ELLIOTT COMPRESSOR

furnishes combustion and lift air for TCC unit



In the compressor area are two Elliott multistage turbine-driven compressors, in addition to the large single-stage unit shown above.

The huge single-stage Elliott compressor shown above has inlet capacity of 74,750 icfm. It serves as a combination combustion air and lift-air compressor for a Thermofor catalytic cracking unit in a southern petroleum refinery. Inlet temperature is 100°F; inlet pressure, 14.3 pisa; discharge pressure, 19.5 pisa. The compressor is driven by a 2200-hp, 3000-rpm Elliott turbine.

Elliott makes a complete line of centrifugal compressor units, consisting of single-stage, multistage and axial flow machines, with integrated Elliott motor or turbine drives. There are 48 frame sizes, permitting accurate matching of compressor to application requirements over the entire range of capacities, from 500 cfm to 600,000 cfm.

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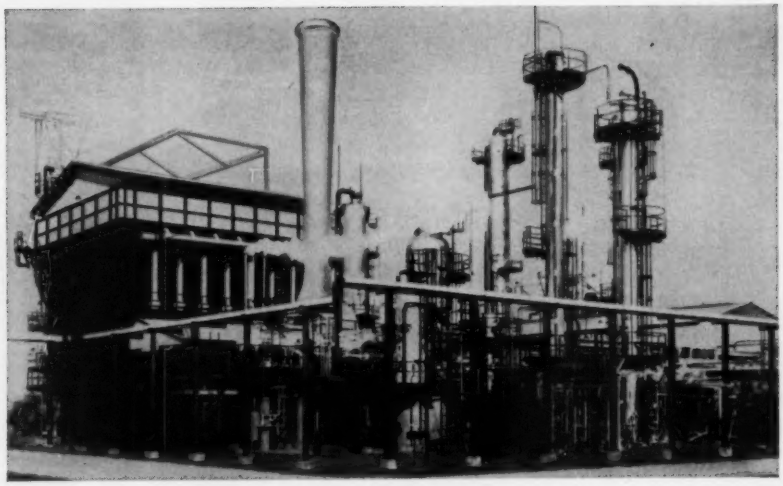
Building . . .



Solar Nitrogen Plans Ammonia Project

A 300-ton-per-stream-day ammonia plant and all offsite facilities will be designed and constructed near Joplin, Mo., for Solar Nitrogen Chemicals, Inc., by The M. W. Kellogg Co. The new plant will use the Kellogg steam methane reforming process. Solar Nitrogen is owned by Standard Oil Co. (Ohio) and Atlas Powder Co. Atlas will operate the new plant, and Sohio Chemical Co. will market the product. Construction will begin in the near future and completion is expected in one year.

The new plant will produce anhydrous ammonia from primary raw materials comprising natural gas, steam and air. It will consist of three major areas encompassing the following steps:

• Gas Preparation: Sulfur will be first removed to insure satisfactory catalyst performance. The sulfur-free gas will be processed in a steam-gas reforming operation taking place in a reforming furnace. The furnace will be followed by a combustion chamber where nitrogen, included with combustion air, will be introduced and reforming completed. In the reforming operation the feed gas will be converted to hydrogen, carbon dioxide, and carbon monoxide. Reformed gas will then be passed through a shift converter producing a shifted raw synthesis gas. In this reaction most of the carbon monoxide will be converted to more hydrogen and carbon dioxide.

• Gas Purification: The raw synthesis gas, which is a crude hydrogen-nitrogen mixture containing carbon dioxide and carbon monoxide, will be compressed and then purified by counter-current extraction, first, using monoethanolamine to scrub out the carbon dioxide at 375 psig followed by cuprous ammonium acetate solution to remove carbon monoxide and residual carbon dioxide at 2,115 psig. This will be followed by a final contact with caustic solution which will serve as a safeguard against incomplete removal of carbon dioxide in the preceding purification steps.

• Ammonia Synthesis: The purified synthesis gas, containing hydrogen and nitrogen in volumetric ratio of 3 to 1, will be further compressed to 4,700 psig and introduced to the circulation system of two synthesis converters in parallel. In the presence of the iron catalyst contained in the converters, a portion of the total hydrogen and nitrogen will be combined in equilibrium reaction to form ammonia which will be condensed from the converter effluent to yield the desired product of the process. The reaction of hydrogen and nitrogen in the converter will supply sufficient heat to maintain the reaction temperature.

Texaco, Inc., has placed three new units on stream at its 60,000-bpd Wilmington refinery, Los Angeles. Included are a 12,000-bpd Platformer, a 12,000-bpd Hydrotreater, and a 26,000-bpd fractionation unit. The cat reforming unit will boost the refinery's cat reformer capacity to 22,000 bpd. Bechtel Corp. built the new units.

Great Canadian Oil Sands, Ltd., has filed an application with the Alberta Oil and Conservation Board for approval on a $100-million project to produce 31,500 bpd of synthetic crude oil from the McMurray tar sands of the Mildred-Ruth Lakes area, 300 miles north of Edmonton, Alta. If GCOS gets the board's okay, construction would begin later this year.

The Standard Oil Co. (Ohio) has started construction of a new $170,000 control laboratory at its No. 2 refinery, Cleveland, Ohio. The Industrial Construction Co. has the prime contract for this new structure—designed by the refinery's Engineering Department with the full use of information and ideas from other laboratories of the company in Cleveland. The lab is to be a one-story, basementless building of brick-faced masonry and will contain approximately 5,000 square feet of space incorporating a total of 15 rooms. It will provide adequate accommodations for equipment and bench space for the efficient quality control testing of many lube oils, waxes and greases produced in the refinery. Some 150,000 individual tests will be conducted in the course of a year. The lab will also provide facilities for the precision blending and packaging of experimental field size batches of new oil and wax formulations. Completion is expected by November.

Signal Oil and Gas Co. will start immediately to rebuild the former Hancock Oil Co. refinery on Signal Hill near Long Beach, Calif., which was partially destroyed by fire two years ago. The two firms were merged at the end of 1958, with Signal surviving as the largest independent in the West. The first step of the long-contemplated reconstruction will provide Signal with a local refining capacity of 15,000-20,000 bpd by the end of 1960. Gasoline will be the Long Beach refinery's sole product. Facilities will be rebuilt in a way that provides for easy and rapid expansion. The ultimate thruput "may reach 50,000 bpd," according to Signal.

Esso Petroleum Co.'s new 100,000-bpd refinery at Milford Haven, England, is estimated to be 70 percent complete. It is to get its first shipment of crude oil this summer and begin operations in early fall.

Great Lakes Carbon Corp. plans to construct a petroleum coke plant at Enid, Okla. The plant, which will cost from $3 to $5 million, will undergo construction in about a year.

Gulf Oil Corp. is considering construction of a refinery in Denmark—possibly on a site at Ebeltoft. The company has been planning new European refineries for quite a while, and investigations are still underway.

Imperial Oil, Ltd. has completed construction of a new hydrofluoric acid alkylation unit at Winnepeg, Man. The plant was built by Bechtel Corp.

India plans to construct a third state-owned refinery. The 10-20,000-bpd plant would be built in the Cambay region of Bombay State. The area where the project would be built has had five test wells drilled—all producers.

what's your best estimate?

. . . a quiz for refinery men who want to keep posted

QUESTION 1. In these countries in the sterling area—England, Scotland, Ireland and India—how many new oil refineries have been built since the close of World War II?

a 4

b 6

c 8

d 12

QUESTION 2. How many of these refineries have been designed, engineered and constructed by Lummus?

a 3

b 5

c 7

d 9

ANSWERS: 1. *The answer is* (d)—*12 new refineries since the war, according to* World Petroleum *magazine.*

2. *Here* (b) *is correct. Lummus has built 5, or 42%, of the new refineries in these countries since World War II, through the Lummus Company Ltd. of London. These five refineries are for Vacuum Oil Company Limited at Corylon, England; California Texas Oil Corporation at Visakhapatnam, India; Burmah-Shell Refineries, Ltd. at Bombay, India; Standard-Vacuum Oil Company, Ltd. at Bombay, India; and the Irish Refining Company, Ltd. at Whitegate, Ireland. Lummus Ltd. maintains a staff of over 400 specialists, and has engineered and constructed hundreds of process plants of all types and sizes in the sterling area from India to Ireland. Lummus Ltd. is one of seven international members of the Lummus group of companies which circles the globe. See Lummus on your next project.*

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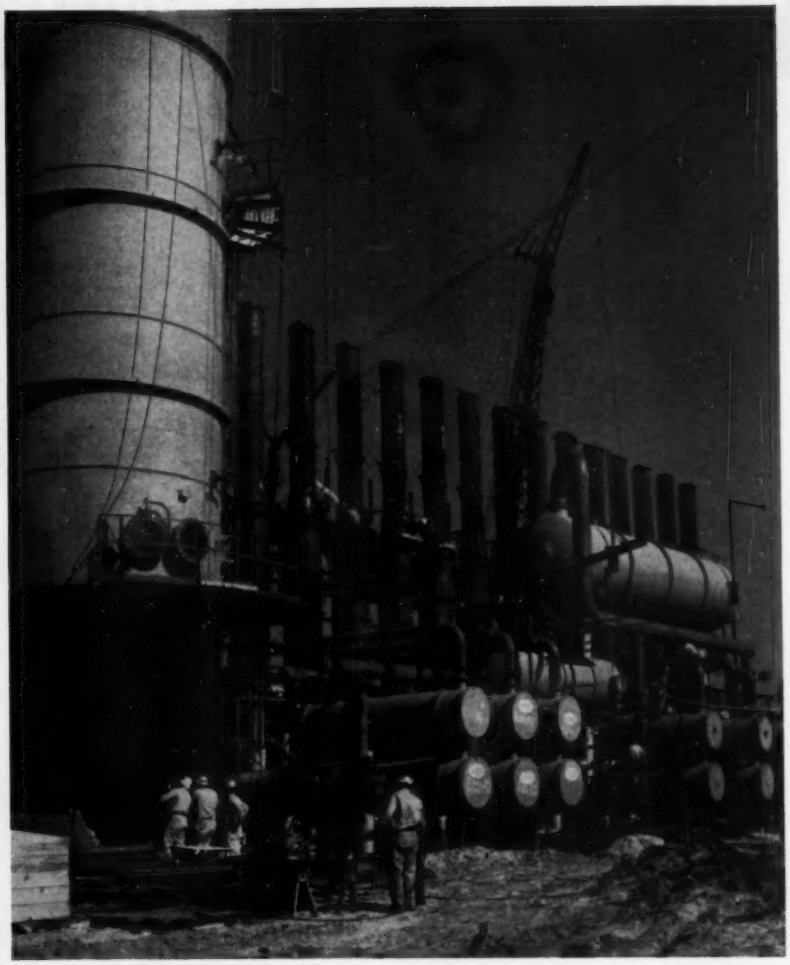
Building . . .



Mobil Constructs Largest Ethylene Unit

The world's largest ethylene unit is being built at Beaumont, Tex., by the Mobil Chemical Co., a division of Socony Mobil Oil Co., Inc. Scheduled for completion early next year, the unit will supply petrochemicals to neighboring plants of Goodyear Tire and Rubber, and Houston Chemical. When the massive towers, furnaces and exchangers are completed, the ethylene unit by itself will be about as big as a small to medium-sized refinery.

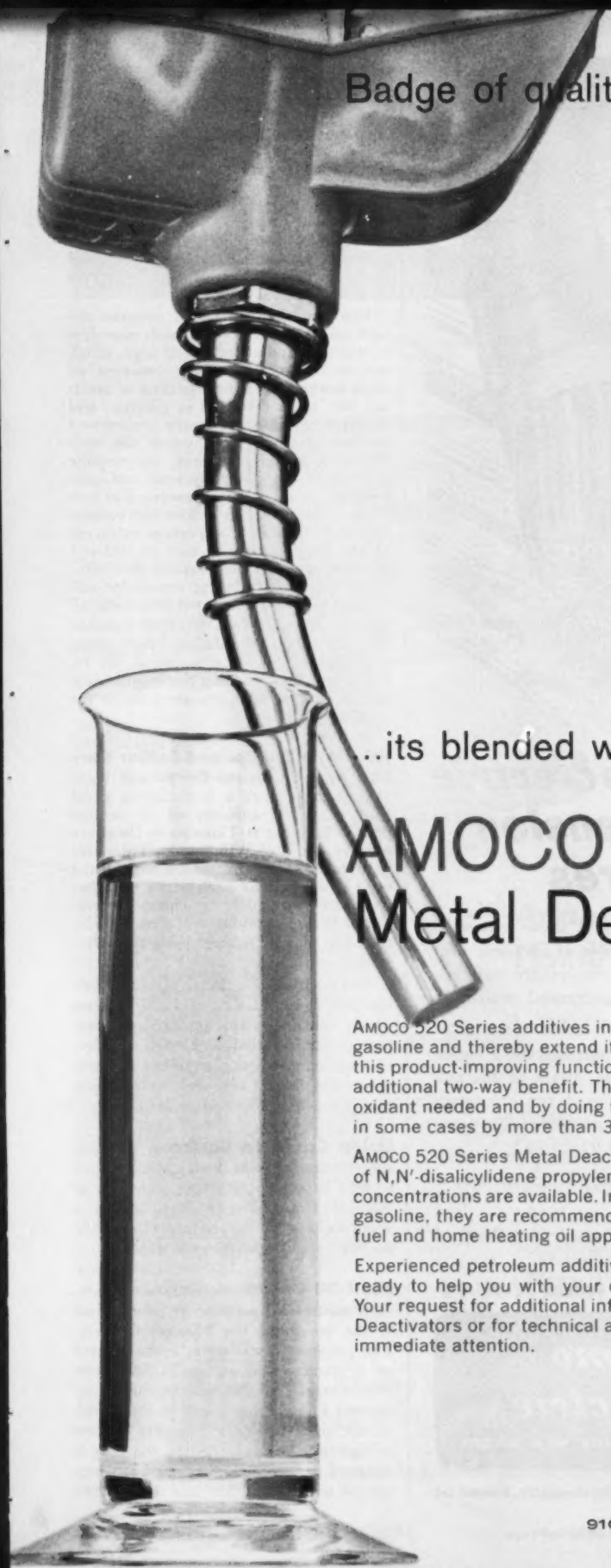
Suntide Refining Co. will begin construction in August of a new Hydrodealkylation unit to cost more than $1 million. It will produce benzene for the manufacture of plastic products. Completion is planned early in 1961.

Sinclair Refining Co. will add an orthoxylene unit to its Houston refinery to produce 66 million pounds per year to fulfill a contract between Sinclair Petrochemicals, Inc., and a Japanese chemical group.

Phillips Carbon Black, Ltd., formed by Phillips Petroleum Co. and Duncan Bros. & Co., Ltd., Calcutta, India, will construct a carbon black plant near Durgapur, India. The plant will be able to produce 22 million pounds of the material. The plant is set to begin production within 17 months.

Olin Mathieson Chemical Corp. will build a multimillion-dollar plant near its inorganic chemicals works at Saltville, Va., to produce anhydrous hydrazine for the U.S. government.

Badge of quality for a gasoline



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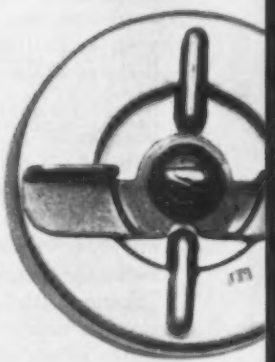
AMOCO 520 Series additives inhibit copper contamination of gasoline and thereby extend its storage life. While performing this product-improving function, these additives provide an additional two-way benefit. They reduce the amount of anti-oxidant needed and by doing this, they lower treatings costs—in some cases by more than 35%.

AMOCO 520 Series Metal Deactivators are solutions of N,N'-disalicylidene propylenediamine in xylene. Three concentrations are available. In addition to their use in automotive gasoline, they are recommended for kerosene, jet fuel, diesel fuel and home heating oil applications.

Experienced petroleum additive specialists from Amoco are ready to help you with your distillate fuel treating program. Your request for additional information about AMOCO Metal Deactivators or for technical assistance will receive immediate attention.



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Individual or duplex thermocouple and extension wires are available in all standard calibrations—many in gages from 14 to 40—insulated with Polyvinyl Chloride, cotton lacquer, Nylon, Teflon, Fiberglass, Asbestos or combinations of these materials. Metallic overbraids of stainless steel and other high-temperature materials provide extra mechanical protection and shielding.

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Building . . .

Sun Oil Co. will begin construction of a $3.6-million propane deasphalter at Toledo, Ohio, in August. Scheduled to be completed by spring 1961, the new plant will be the "largest propane deasphalter in the United States," says the company. Rotation of the plant's disc contactors will assure thorough mixing of residual fuel oil with propane used in the process as a solvent.

Heart of the 10,500-bpd propane deasphalter is three towers, each nine feet in diameter and about 70 feet high, which enclose the rotating disc contactors. In these towers, the lighter portion of residual fuel oil is dissolved in propane and separated from the heavy undissolved portion by gravity. Because of the wide difference in boiling points, the propane is stripped out easily by heat and continuously re-used in the process. The new plant is designed "to reduce the volume of heavy fuel oil. The portion extracted by the propane will be used as catalytic cracking stock for manufacture into additional gasoline while the remainder will be used as fuel or converted into asphalt."

Foster Wheeler Corp. has been awarded the contract for the design, engineering, procurement and construction of the refining unit. Sun is doing the engineering, design, drafting and procurement for the auxiliary facilities.

Tidewater Oil Co. and Collier Carbon and Chemical Corp. will build as a joint venture a naphthalene plant with an initial capacity of 50 million pounds per year at Tidewater's Delaware refinery, south of Wilmington. Tidewater will operate the plant, which will fill the need in the East for high-purity naphthalene used principally by chemical companies in the manufacture of raw materials for plastic, rubber, paint and dyestuffs.

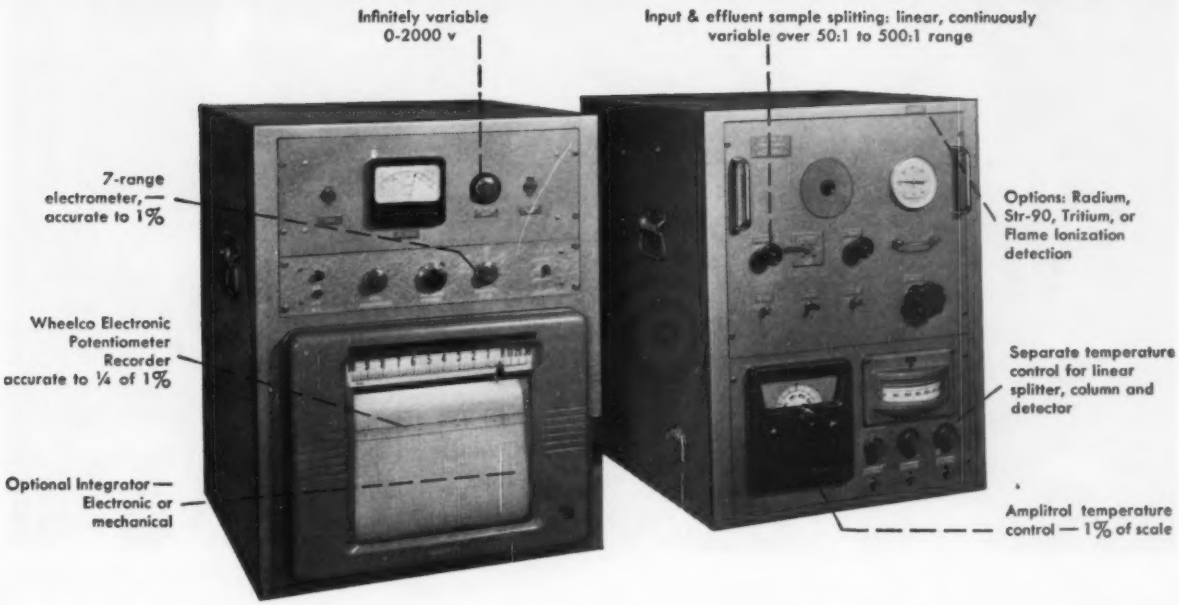
The multi-million dollar plant will utilize a Union Oil Co. of Calif. process which converts alkyl naphthalenes into high purity naphthalene. Design is underway with construction expected to begin before the first of the year and completion planned by the end of 1961.

Union Carbide Caribe is planning construction of what it says would be the world's largest polyethylene plant. To be built at Ponce, Puerto Rico, within a year, the unit would produce 110 million pounds of polyethylene per annum.

Shell Oil Co. plans to construct a natural gasoline and propane recovery plant at the mouth of the Mississippi River. The proposed installation, to be located on a six-acre site at Shell's Southwest Pass central facilities, will be the oil industry's first gasoline plant at the mouth of the river. Using a process of low refrigeration and absorption, the unit is designed to extract an estimated 725 barrels of natural gasoline and 400 barrels

Qualitative & Quantitative

with Barber-Colman Gas Chromatography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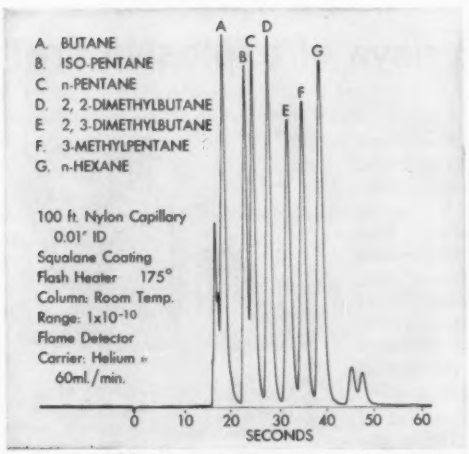

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vital equipment is undamaged by 3 days of explosive fire!

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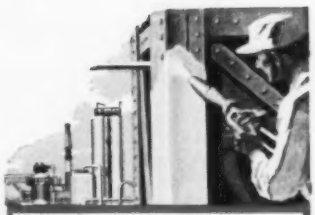
Find out more about this newest of fire protection ideas, and about the application of L. W. Blazecrete throughout the petroleum industry. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



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Building . . .

of propane daily. Although the plant is designed for an original capacity of about 75 to 80 MMcf of gas a day, plans include a program of expansion which could double plant capacity.

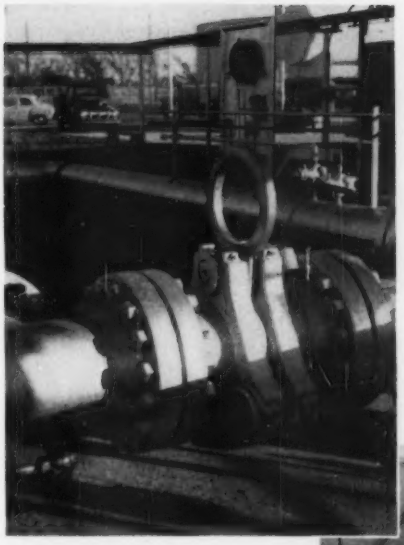
Equipment will be mounted on three concrete platforms raised above the marshland on piles. One platform will be for processing equipment, another for generators and refrigeration and a smaller one for a direct fired heater. The refrigeration unit will lower the temperature of the incoming gas to —20° F. Much of the processing will be monitored, adjusted and controlled from a centralized control panel. Construction is expected to take about a year.

Continental Oil Co. plans a $2.2-million expansion of its research and development facilities at Ponca City, Okla., which will double the size of the main research laboratory and add 135 scientific personnel in the next five years. Included will be a $1.9-million addition to the main research laboratory built at Ponca City in 1952, and a $300,000 laboratory services building. The research addition will connect with the existing laboratory and will cover some 40,000 square feet of space, about the same as the present main laboratory. Work will start late this fall, with completion expected in early 1962.

Sun Oil Co. is planning further expansion in petrochemicals in a number of lines, says Joseph N. Pew, Jr., chairman of the board. Robert G. Dunlop, president, said it is "somewhat undecided" at the moment whether new petrochemical products will be manufactured by Sun on its own, or in affiliation with other companies along lines of its partnerships with Olin Mathieson Chemical Corp. and American Viscose Corp.

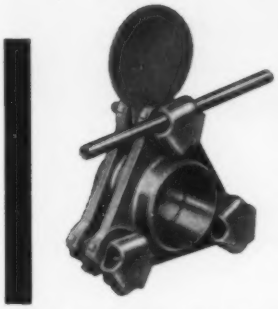
Sinclair-Koppers Chemical Co. has awarded the contract for design, engineering and construction of its new styrene monomer plant to Badger Manufacturing Co. The new plant, with a design capacity of 70 million pounds per year, will be the largest of its type, and the first licensed by Cosden Petroleum Corp. under its "styrene-from-gasoline" process, developed jointly by Cosden and Badger.

The new company will purchase the ethylbenzene content of a mixed xylene stream produced in Sinclair's Houston aromatics extraction unit constructed by Badger in 1959, and, in a single process step, recover the hydrocarbon in a pure form. Subsequent dehydrogenation and styrene recovery and purification will produce plastic-grade monomer. (The Cosden plant, at Big Spring, Texas, has been turning out styrene monomer of

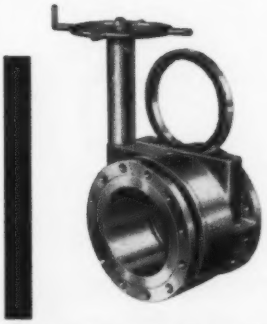


FAST, EASY, POSITIVE
LINE BLINDING

Hamer
Line Blind Valves



The famous 3-Bolt Hamer Line Blind Valve has set the standard for positive, dependable, economical line blinding in all industries.



Handwheel operated Hamer Rigid Type Line Blind Valves are ideal for installation where conditions prevent spreading the line to reverse the spectacle plate.

FAST . . . because one man can reverse the spectacle plate from open to closed position in a matter of minutes.

EASY . . . because bar or handwheel operation provides tremendous leverage for spreading and tightening the hubs that hold the spectacle plate. Wedges, hammers, wrenches needed for spreading conventional flanges are eliminated.

POSITIVE . . . because nothing seals as securely and permanently as the solid spectacle plate clamped between the hubs of a Hamer Line Blind Valve.

Ask your nearest Hamer Line Blind Valve specialist about the multiple advantages of installing them wherever positive line shut-off is essential. Write for new Hamer Valve Catalog 60.

WECO
WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS
Division of CHIKSAN COMPANY a subsidiary of FOOD MACHINERY AND CHEMICAL CORPORATION
HV-2-60
fmc

WECO UNIONS

CHIKSAN SWIVEL JOINTS

HAMER LINE BLIND VALVES

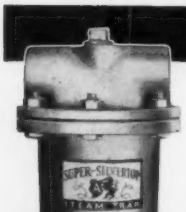
HAMER PLUG VALVES

For more data on advertised products, use Readers' Service Cards, last page.

Is there an all-purpose steam trap to meet all requirements? There is no existing single purpose trap to answer all trapping problems. Instead, Anderson offers four different trap designs, each engineered for a definite type of application.

For your general purpose applications, the answer is Super-Silvertop Steam Traps. Where fast heating-up is required, Anderson Heat-Kwik Combination Open Float or Thermostatic Traps are without an equal. Ideal for outdoor, freeze-proof installations, insist on our Quik-Flex Thermostatic Steam Traps. For draining condensate from steam or moisture from air and gas equipment, Anderson continuous flow type Float Traps are unbeatable.

For the highest efficiency in traps for all purposes, make your selection from Anderson's complete line of traps. Mail coupon for our engineering catalog, "How To Select Steam Traps and Other Fluid Specialties".



A TRAP FOR EVERY PURPOSE

THE V. D. ANDERSON COMPANY
division of International Basic Economy Corporation
1953 West 96th Street • Cleveland 2, Ohio

Please send a copy of your new engineering booklet, "How to Select Steam Traps and Other Fluid Specialties".

Name_____ Title_____
Company_____
Address_____
City_____ Zone_____ State_____

ANDERSON *SUPER•SILVERTOPS*

Building . . .

99.6 percent minimum purity since February 1957.) The plant will be erected on a new site in Houston (Pasadena), Texas, with completion date scheduled for mid-1961. The entire output of the new plant will be sold to Koppers Co., Inc.

Japan Synthetic Rubber Co. has completed construction of a $30-million synthetic rubber plant at Yokkaichi, Japan. Designed by Blaw-Knox Co., the plant is located 25 miles from Nagoya on Ise Bay in the general area of a major petrochemical complex. An 82-acre site provides for expected expansion. Marking a new industry in Japan, the manufacture of synthetic rubber is expected to expand rapidly. The new plant was designed to produce an annual output of 40,000 metric tons of SBR crumb rubber and 5,000 metric tons of synthetic latex. This compares to 1959 Japanese rubber consumption of 190,000 metric tons, expected to reach 220,000 tons this year and 300,000 tons by 1965.

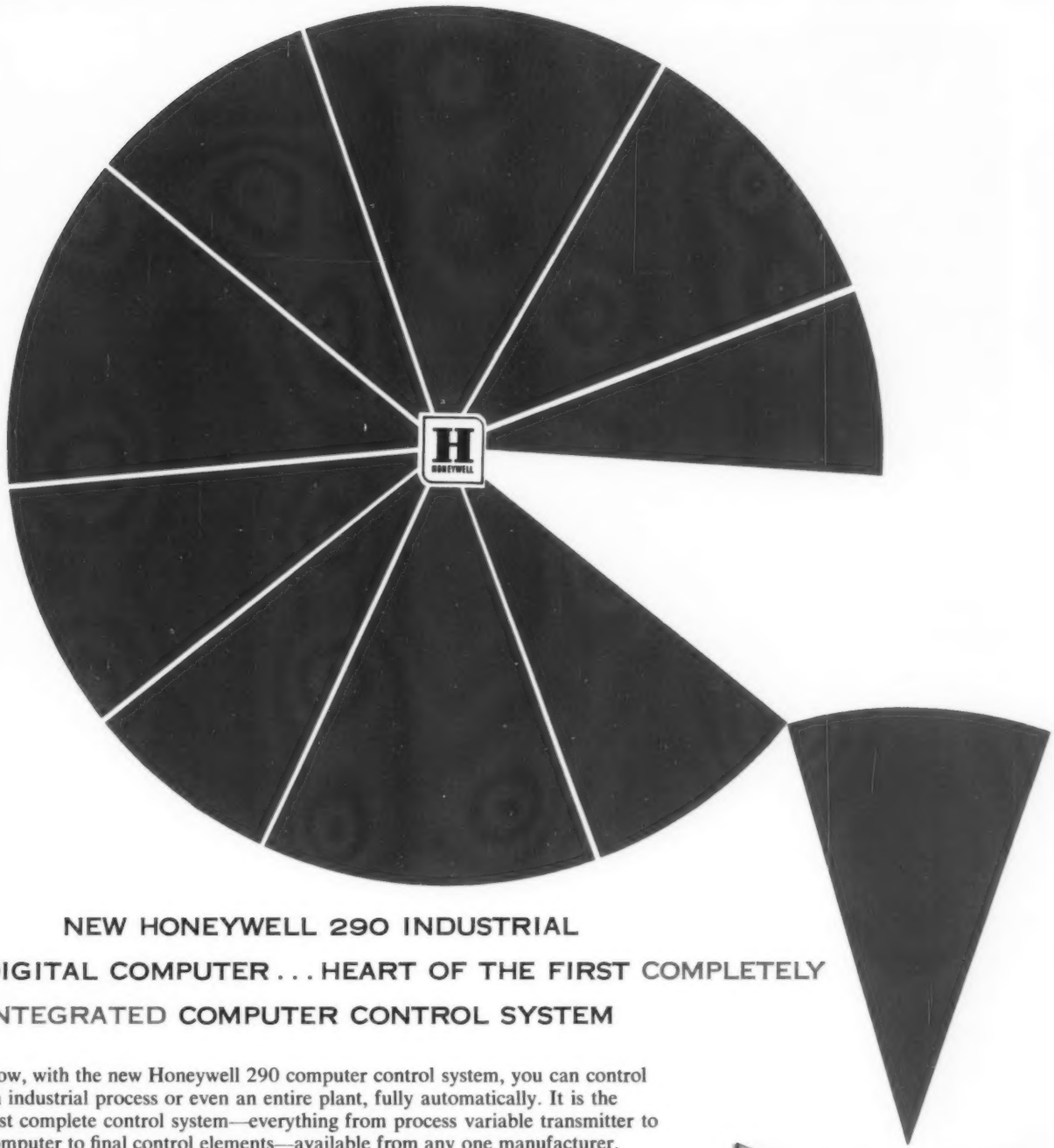
Montecatini Co. has signed an agreement with Uniao Fabril do Azoto of Portugal for the construction of a 40,000-metric-ton-per-year urea plant at Labradio, near the town of Barreiro on the Tagus River. The plant is being engineered by The M. W. Kellogg Co. and will incorporate total recycle in the liquid phase. This allows full utilization of ammonia feed in the formation of urea. Since the process is versatile, the alternative of partial recycling of ammonia will also be possible. This partial utilization of feed for the urea synthesis will permit production of nitrogen compounds other than urea to accommodate existing market demand for such products.

Ketjen-Carbon, Ltd., a subsidiary of Royal Sulfuric Acid Works Ketjen, Ltd., Amsterdam, Holland, and Godfrey L. Cabot, Inc., has completed construction of Holland's first carbon black plant. Built in one year, the 24,000-ton-per-year unit manufactures five types of carbon black.

Koppers Co. plans to increase by 15 percent facilities for production of polystyrene plastic at its Kobuta, Pa., plant. The project is part of an over-all Koppers expansion of polystyrene plastic and styrene monomer facilities.

Humble Oil & Refining Co. will increase butyl rubber production at its Baytown Refinery from 125 million pounds per year to more than 170 million pounds by the second quarter of 1961. The Baytown expansion project comes on the heels of a major upswing

For more data on advertised products, use Readers' Service Cards, last page.

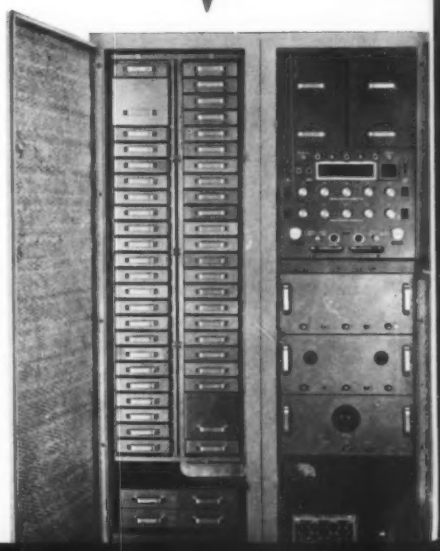


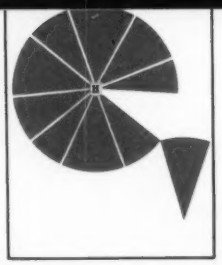
NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HEART OF THE FIRST COMPLETELY INTEGRATED COMPUTER CONTROL SYSTEM

Now, with the new Honeywell 290 computer control system, you can control an industrial process or even an entire plant, fully automatically. It is the first complete control system—everything from process variable transmitter to computer to final control elements—available from any one manufacturer. Heart of the system is the new Honeywell 290 industrial digital computer.

The Honeywell 290 is the most powerful computer in its class, despite its small size, low cost and low power consumption. It performs, for example, 8,000 additions, 1,250 multiplications or 400 square root extractions per second. Unique, powerful macro-instructions help make the 290 easy to program, reduce working memory requirements and increase operating speeds. These special instructions augment the basic instructions, and eliminate many special subroutines.

The combination of high-speed operation and the reliability of conservative solid-state circuitry brings optimum control of many types of industrial processes. In addition, the Honeywell computer control system can compile complex operating guides, correlate data, and reduce huge masses of acquired data into immediately usable information for monitoring or optimizing process operations.





NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HIGH SPEED, PARALLEL OPERATION, EASILY PROGRAMMED

The high computation speed of the Honeywell 290 provides many advantages in on-line monitoring and control of industrial processes:

- Higher sampling rates give closer control because each variable can be checked more frequently.
- More work can be accomplished in a given time.
- Checking and validity routines can be used extensively.
- Tasks other than process control can be accomplished either through time-sharing or through priority instructions in the computer program.

The Honeywell 290 is the first industrial digital computer to use parallel operation within the computer. All digits in a multi-digit number are transferred *simultaneously* from one element to another within the computer . . . in one count of the clock. Therefore a much slower clock rate can be used. Components are operated far below their maximum ratings—greatly increasing overall reliability, while permitting many thousands of program steps to be executed each second.

The computer combines both magnetic core and drum memory. Main memory is the magnetic core type, and it can be supplied with capacities of 1,024, 2,048 or 4,096 words. A magnetic drum memory with a capacity of either 4,096 or 8,192 words is also provided—a total capacity of 12,288 words. This combination gives you the speed and random accessibility of core memory with the program permanence of drum memory.

The Honeywell 290 Computer operates with standard, field-proved Honeywell process instrumentation in a completely integrated system of control. *ElectriK Tel-O-Set* transmitters feed process variable input data to the computer. These solid-state, two-wire transmitters convert temperature, pressure, flow and other measurements into electric signals. Various types of computer peripheral equipment are supplied by Honeywell to add flexibility to the system and make it easily expandable to meet future requirements. This equipment includes analog-to-digital and digital-to-analog converters, high-speed paper tape readers and punches, visual displays and electric typewriters. Honeywell *ElectriK Tel-O-Set* transducers make the computer completely compatible with existing pneumatic process measuring and control instruments.

Get complete details from your nearby Honeywell field engineer. Or write for Catalog C-290. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

75th YEAR — PIONEERING THE FUTURE

Honeywell

First in Control

SINCE 1885

Building . . .

in butyl demand. Humble announced last December two similar projects at its Baton Rouge refinery. The first of these projects, representing a 44-million-pound-per-year increase in butyl production, was completed in May.

The second expansion at Baton Rouge will provide facilities for manufacturing an added 40 million pounds a year of butyl. This project is well under way, and completion is scheduled for the second quarter of 1961. After completion of the 84-million-pound expansion at Baton Rouge and the 45-million-pound increase at Baytown, Humble can manufacture more than 350 million pounds a year of butyl.

Mitsui Petrochemical Corp. is teaming with E. I. duPont de Nemours & Co. to seek authorization from the Japanese government to establish a company capitalized at $8 million to meet the growing demand for polyethylene in Japan. Expected capacity of the new plant is 27,000 tons per year. Demand for polyethylene in Japan is expected to reach 114,000 tons by 1963. Polyethylene consumption in 1959 was 54,533 tons, with 21,280 tons produced in Japan.

Shell Chemical Co. plans to construct a polydiene rubber plant at Carrington, England. Work is to begin immediately on the unit, which will manufacture polybutadiene and polyisoprene, using a process developed by Royal Dutch Shell. The unit will take three years to complete.

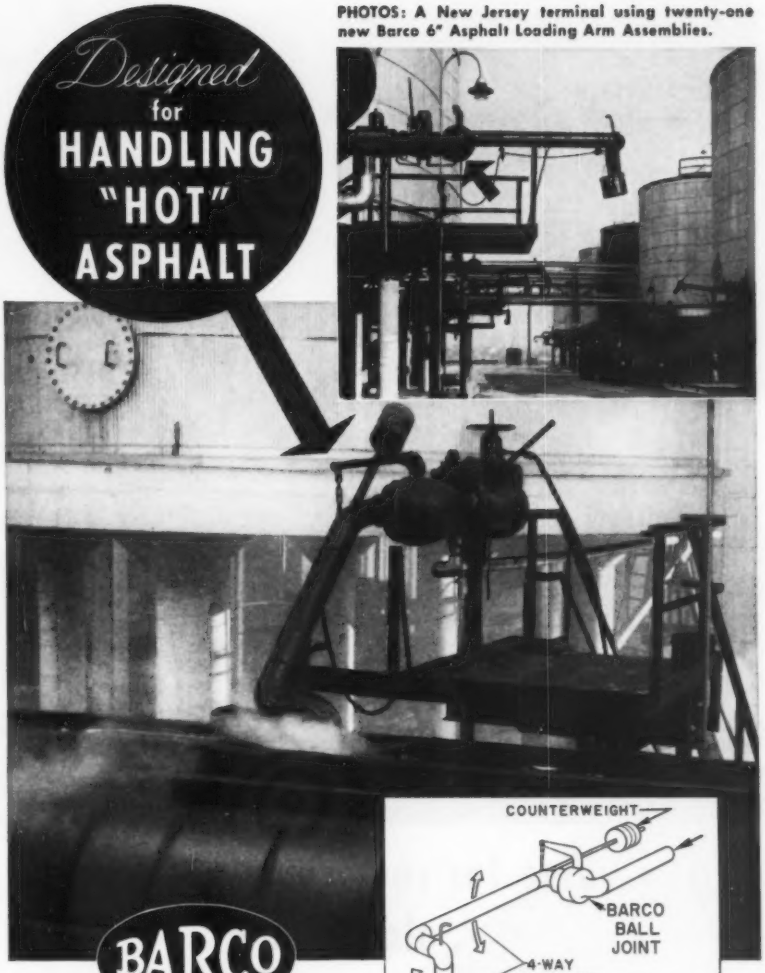
Shell Oil Co. of Canada, Ltd. is considering purchase of a site near Calgary, Ont., as a possible refinery location. An option on a 310-acre tract was negotiated some time ago. The company plans to start engineering studies and surveys soon.

Sinclair Oil Corp. has completed facilities for production of liquefied petroleum gas at East Chicago, Ind. Brought on stream was a modern unit for recovery of propane, and related equipment, including large storage vessels and racks for loading the fuel into tank cars and trucks. Daily capacity ranges to 100,000 gallons.

Erdolchemie G.m.b.H. has completed the second stage of its petrochemical plant at Dormagen, near Cologne, West Germany. The company, owned by British Petroleum Co. and Farbenfabriken Bayer A. G., completed the initial stage of its construction during 1959, and the company's first four processing units have been operating for 12 months.

Units being commissioned include a cracking and gas separation plant, which

PHOTOS: A New Jersey terminal using twenty-one new Barco 6" Asphalt Loading Arm Assemblies.



"Ball Joint" LOADING ARMS

CHECK THESE POINTS! Here's why more and more refineries and chemical processing plants now use Barco Flexible Ball Joint Loading Arms for handling ASPHALT and other high melting point fluids:

- ☑ **MADE FOR HIGH TEMPERATURES!** 400°, 500°, or 600°F present no problems.
- ☑ **ECONOMY!** Simple construction; fewest number of parts. One Barco Ball Joint, combining 360° swivel motion with 30° angular movement, does the work of more complicated "double" ball bearing swivel joints.
- ☑ **NO LUBRICATION!** No ball bearings in Barco flexible joint to require frequent greasing. No trouble with gumming up of ball races due to "oozing."
- ☑ **FIRE SAFE!** Barco Ball Joints have passed rigid Fire Tests for refinery and chemical plant service.
- ☑ **STEAM JACKETED!** Available with jacketed construction, or easy to apply steam tracing and insulation.
- ☑ **NEW COUNTERWEIGHTED STYLES!** Standard and custom designed loading arm assemblies can be furnished by Barco, complete. or joints only for use with standard pipe.

Inquiries are invited; ask for catalog.

BARCO MANUFACTURING CO.
5421 Hough Street, Barrington, Illinois
The Only Truly Complete
Line of Flexible Ball, Swivel, Swing and Rotary Joints
In Canada: The Holden Co., Ltd., Montreal

SEND FOR CATALOG 2158

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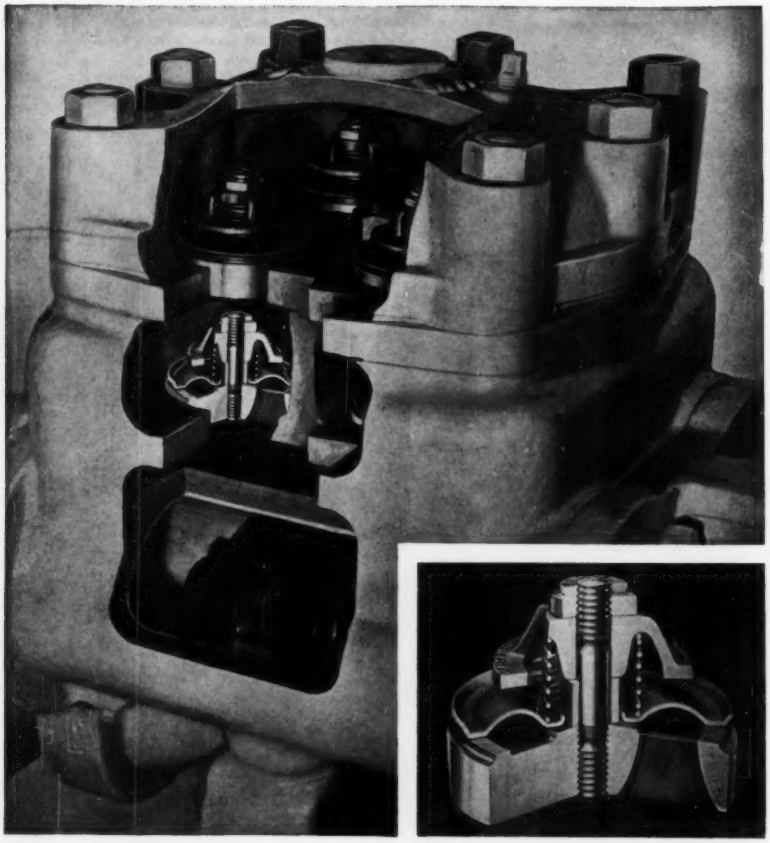


The valve for reciprocating pumps . . . old or new

Because they offer a happy combination of dependability, efficiency and extra life, DURABLA Valves are a credit to any reciprocating pump. Mechanically and metallurgically speaking, they will operate freely under temperature-pressure extremes, with highly corrosive fluids and in any position.

In a DURABLA Valve Unit, only "point contact" is made by the valve member on the sleeve, so it can't bind or hang-up. Due to its unique arched design, neither will it warp. The new V-7* taper-locked stud can be screwed down tight into the seat without any possibility of galling or breakage. And a self-locking nut and "drop-on" guard assure quick and easy inspection of working parts —without stud or seat removal.

Standard equipment on many new pumps, DURABLA Valve Units are also used throughout the world to re-valve older pumps. They come in fifteen sizes, designed to meet over 300 variations in installation requirements.

Write for new booklet PE 80.

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, New York

DURABLA®

DM-34

Building . . .

is designed to treble Erdölchemie's previous output of ethylene.

Ethylene-using units going into service include an ethanol (synthetic alcohol) plant, and a second plant for producing ethylene oxide, which is used, among other things, in the manufacture of glycols.

One of the units recently commissioned by Erdölchemie is a hydrotreater, which removes gum-forming material from the gasoline produced as a by-product by the ethylene units. This plant, which was developed and designed by BP, is believed to be the first one of its kind of commercial size for treating steam-cracked gasoline.

United Refining Co. has started construction of a 1,100-bpd alkylation unit at Warren, Pa. The $1.3-million unit, to be completed late this year, is being engineered and constructed by The M. W. Kellogg Co.

United States Sulphur Corp. has opened a sulfur manufacturing plant at High Island Dome, 38 miles east of Galveston, Texas. Texas Gas Corp. laid a 9-mile pipe line to the new unit, which is to produce 1,200 tons per day of sulfur by late summer.

Witco Chemical Co. is planning a 30-million-pound-per-year phthalic anhydride plant, to be built on the East Coast. The unit will employ a naphthalene oxidation process, and is to be completed in 1961. Witco currently operates a 20-million-pound-per-year plant in Chicago.

Witco Chemical Co.'s Ultra chemical works, Chicago, is planning construction of a detergent and detergent chemicals plant. The unit is to produce 30 million pounds per year of dodecyl benzene sulfonate.

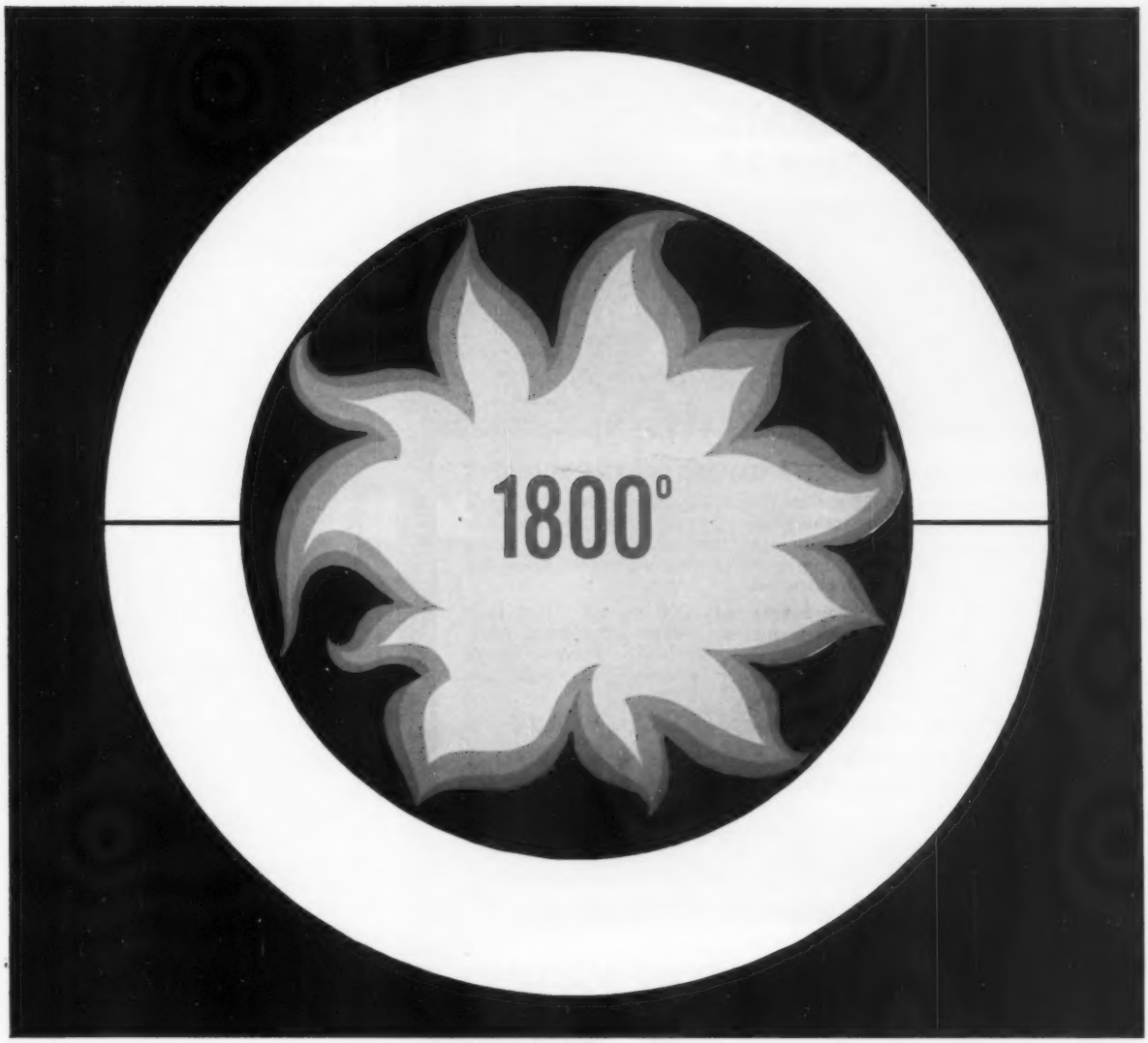
U.S.S.R. plans to construct a $12.5-million refinery at Assab, Eritrea, in Ethiopia. The plant will be built under economic aid protocol signed recently in Addis Ababa. The agreement also provides for exploration in Western Ethiopia.

British Petroleum Co. is planning to construct a lubricating oil plant somewhere in Australia. The plant's capacity would be in the neighborhood of 100,000 long tons per year, and would cost about $20 million.

Shell Oil Co. has applied for customs exemptions in San Salvador, in order to build a refinery there. The new plant would be located near La Union at the eastern end of the tiny country.

Saudi Arabian Refining Co. (SARCO) has named The Ralph M. Parsons Co. to design and construct a 20,000-bpd refinery on the coast south-

For more data on advertised products, use Readers' Service Cards, last page.



NOW CALSILITE-HI TO 1800°F

New Ruberoid Calsilite-Hi insulation for soaking heat to 1800°F. It's light, strong and so economical it can be used on all types of jobs. Calsilite-Hi is ideal for both insulation and fireproofing.

Calsilite-Hi, a molded calcium silicate insulation, extends the Ruberoid insulation line to the upper temperature limit of 1800°F. Available in half-sectional, three segmental and block form, it can be used as fireproofing for walls, partitions and ceilings as well as insulation for piping and equipment.

Calsilite-Hi is light and easy to install. It cuts and mitres quickly, smoothly and is gentle on hands. What's more, it keeps its strength even when wet, does not soften or fall off. Returns to its original thermal efficiency when dry. Resists most chemicals and alkalis in industrial concentrations.

For additional specifications or samples of Calsilite and Calsilite-Hi insulation, write: The Ruberoid Company, 500 Fifth Avenue, New York 36, New York.

THERMAL CONDUCTIVITY
(BTU/sq. ft./inch/hr./°F.)

400°F. (Mean)	0.54
600°F. (Mean)	0.64
800°F. (Mean)	0.74

Density 13.5 lbs. per cu. ft.

Compressive Strength
5% deformation (Min.) 135 lbs. psi.

Flexural Strength 75 lbs. per sq. in.

Change under Soaking Heat
24 hrs. @ 1800°F.

Loss in weight	5%
Linear Shrinkage	1.5%

The RUBEROID Co.®

For more data on advertised products, use Readers' Service Cards, last page.

WE WEAVE ACCURATE "WORKING OPENINGS"

IN WOVEN WIRE SCREEN AND WIRE CLOTH PRODUCTS

Whether you are grinding, sizing, scalping, dewatering or filtering it's the accuracy of the "working opening" that makes the difference in woven wire screen and wire cloth products. We pride ourselves in weaving accurate "working openings", an engineered screening surface to meet your specification.

First, the best metal or alloy is selected—hard enough to withstand the abrasive action—ductile enough not to break under stress. Next, the best wire diameter and crimp are determined. Then we weave wire screen or wire cloth around accurate "working openings" best suited for your screening application.

FREE! Write for bulletin 160 giving complete details and facilities.

THE CLEVELAND WIRE CLOTH & MFG. CO.
3571 EAST 78th STREET • CLEVELAND 5, OHIO

you don't have to increase pump speed

...to get GREATER PUMP VOLUME

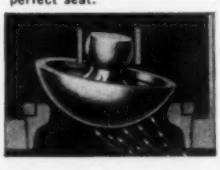
in fact ... the revolutionary Royal Crown Pump Valve increases pump volume with less pump speed! Here's how it operates: Valve is guided by a frictionless ball stem (not a rigid guide) which allows it to oscillate and turn freely with the fluid stream with a minimum of resistance. The result: greater pump volume at a slower pump speed for maximum pump efficiency and economy. Royal Crown Valves have only three separate parts which assures long, trouble-free service. Adaptable to all reciprocating pumps and all liquids.

Royal Crown PUMP VALVES

WRITE FOR FREE LITERATURE TODAY

Round valve surface is streamlined. No crossbars or obstructions in seat to restrict the flow of liquid.

Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing a lapping action—a perfect seat.



Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

MADSEN WORKS / BALDWIN-LIMA-HAMILTON Construction Equipment Division

14120 E. ROSECRANS AVE., P.O. BOX 38, LA MIRADA, CALIFORNIA
BALDWIN-LIMA-HAMILTON CORPORATION, LIMA, OHIO

Building . . .

west of Jeddah. The $20-million plant will be built on a 700-acre site, with construction work to begin immediately and be completed late in 1962. Principal components of the refinery include crude and vacuum distillation units, asphalt plant, desulfurizers, catalytic reformers, and an Ethyl fluid unit. Refined products will include gasoline for autos and aircraft, jet fuel, kerosine, diesel fuel, butane and propane, fuel oil, and bunkering oil. Crude oil will be shipped to the refinery from the Eastern Province of Arabia.

SARCO is a new Saudi Arabian company conceived by Prince Mohammed ben Saud. Approximately half the stock in the company is being offered to the Saudi public. The other half has been subscribed by the founders who are Saad ben Saud ben Abdul-Aziz, Musaed ben Saud, Khaled ben Turkey, Abdulla Al-Suleiman, Dr. Ahmed Fahim, Rashad Dabbagh, and the Riyad Bank (Saudi Limited Co.). It is believed this is the first time the Saudi public has been invited to participate in an organization of the size and scope of Sarco.

Shell Oil of Chile, Ltd., has inaugurated a new luboil batch blending plant at Vina del Mar, near Valparaiso. The plant has a rated capacity of about 9,000 tons a year. It was completed about a year after its construction had been approved.

Iraq plans to construct a sulfur recovery plant at Dibis, near Kirkuk. The unit, to be built under agreement with the USSR, will initially produce 65,000 tons of sulfur and 110,000 tons of sulfuric acid.

Ethiopia is planning construction of its first refinery. The U.S.S.R. has allocated $12.5 million in economic aid for the project. The refinery will be built at Assab.

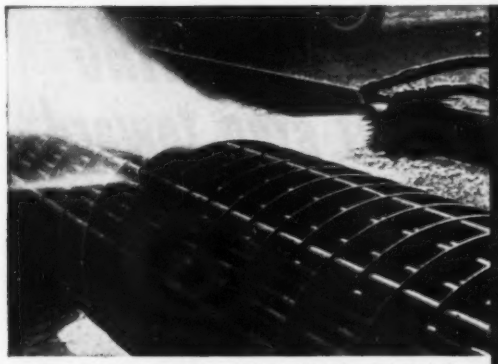
St. Paul Ammonia Products, Inc., proposes to spend $4 to $8 million on expansion of its nitrogen plant at Pine Bend, Minn.

British Hydrocarbon Chemicals, Ltd., will build a butadiene extraction plant at Grangemouth, Scotland, as part of its $14-million petrochemical expansion program. Fluor Engineering & Construction Co., Ltd., will engineer and build the plant.

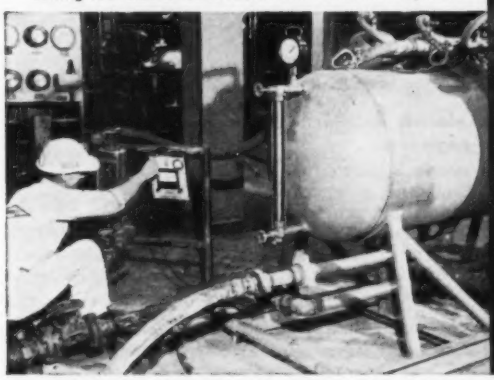
Canadian Husky Oil, Ltd., will spend $1 million for new construction and alteration of its Fort William, Ont., 4,000-bpd refinery to enable the refinery to store and operate on Western Canada crude as well as the Saskatchewan medium-gravity crude the plant now uses.

For more data on advertised products, use Readers' Service Cards, last page.

A new mark for a nation-wide cleaning service . . . DOW



Jetting tool cleans tubes fouled with coke and asphalt.



New mobile foam-cleaning equipment cuts cleaning costs.

Cleaning missile lines and components requires tolerances as close as 150 microns.

DOW INDUSTRIAL SERVICE

Industrial Cleaning. Dow Industrial Service, now a separate division of The Dow Chemical Company, offers the only nation-wide chemical cleaning service for virtually all types of industrial processing equipment. This is an expansion of the cleaning service developed over the past 20 years. Dow is currently servicing entire plants as well as doing special cleaning jobs for both large and small companies.

Dow Industrial Service research in industrial chemical cleaning has developed specialized mobile equipment and techniques, some of which are pictured above. These highly efficient techniques are improving plant productivity and reducing equipment downtime in all industries using steam generators, condensers, heat exchangers, towers, water and product lines, water wells and tanks, or similar process equipment.

Product Sales and Service. The sale of specialized chemical products, scientifically formulated to be of use in specific industrial processes and to give the necessary technical service in their use, is the job of Product Sales and Service. Purifloc* N17 is an outstanding new flocculant cleared by USPHS for use in potable water.

Laboratory Service. Because of the rapid development of chemical products for the municipal and industrial waste and water treatment areas, Dow Industrial Service will take on the service-selling of those products. Also, a consulting laboratory service for municipal and industrial waste and water treatment is provided.

You'll find Dow Industrial Service offices and stations with specialized cleaning equipment and experienced personnel in all major industrial areas. For more information, write to Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio. *TRADEMARK

DOW INDUSTRIAL SERVICE DOW *Division of THE DOW CHEMICAL COMPANY*

PRODUCT IMPROVEMENT WITH

PETRECO

EFFICIENT DESALTING is the first step toward PROFITABLE REFINING

Salt removal is now a routine operation in all modern refineries. With the need for effective desalting widely recognized, the main problem today is the selection of that equipment which will do the most efficient job at the least possible cost.

When you need new or additional desalting facilities, keep these points in mind:

■ ***The first electric desalter was designed and installed by Petreco engineers.***

This was nearly a quarter of a century ago. The subsequent years of solid, practical experience in dealing with (and solving) desalting problems all over the world now enable Petreco desalting to yield salt removals in the 98-100% range. The fraction of a cent per barrel desalting cost is saved many times over by the gains in refining efficiency resulting from a clean charging crude.

■ ***The first chemical desalter was designed and developed by Tretolite engineers.***

Tretolite chemical formulations were the first ever to be used in desalting. Tretolite desalting units are the only exclusively chemical desalters ever to be sold and installed in the refining industry and are currently used to desalt a million and a half barrels per day. In fact, every important development in crude oil desalting has resulted from the Petrolite research, engineering and development program.

YOU GET

98-100% SALT REMOVAL

WITH PETRECO ELECTRIC OR

TRETOLITE CHEMICAL DESALTING

Because Petreco offers both kinds of desalters, the company has no "axe to grind". This means that you get an honest and objective appraisal of the method best suited to your operation.

There is no other desalting equipment on the market today that can offer you comparable efficiency of design. The operating records from installations around the world *prove* it! There's no other company, either, that can offer you Petreco's fund of desalting technology or Petreco's rich background in this highly specialized field.

DT-60-1

PETROLITE CORPORATION

PETRECO DIVISION

3202 South Wayside Drive (P.O. Box 2546), Houston 1, Texas
1390 East Burnett Street (P.O. Box 7216), Long Beach 7, California

CANADA: Petreco, 4528 Stanley Drive, Calgary, Alberta
ENGLAND: Petrolite Limited, 20 Savile Row, London W.1
GERMANY: Petrolite Anlagenbau und Vertriebsgesellschaft m.b.H., Frankfurt a. M.
VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES

ARGENTINA: S. A. ASTAR, Tucuman 1438, Buenos Aires
BRAZIL: WERCO, Ltda., Avenida Rio Branco 57-s/1410-11, Rio de Janeiro
COLOMBIA: W. F. Faulkner, Calle 19, No. 7-30, Office 807, Bogota
ITALY: NYMCO, S.p.A., 9 Lungotevere A. da Brescia, Rome
JAPAN: Chiyoda Chemical Engineering and Construction Co. Ltd., Tokyo
KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait
MEXICO: R. E. Power, Sierra de Mijes No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
TRINIDAD: Neal and Massy, Ltd., P. O. Box 544, Port of Spain

Building . . .

Firestone Tire & Rubber Co. is conducting a $120-million worldwide construction and modernization program, with building of tire manufacturing plants at Calgary, Alta., Bethune, France; and synthetic rubber plants at Port Jerome, France, Bareilly, India, and Orange, Texas.

Nopco Chemical Co. has completed construction plans for an isocyanates plant in New Jersey. Expected to be producing by January 1962, the installation will have a design capacity of 10 million pounds per year, expandable to twice this figure. Main product of the plant will be toluene diisocyanate. Cost of the plant is estimated at $7 million.

North Africa crude oil stabilization facilities at Hassi Messaoud in the Sahara oil fields will expand with a new plant which will put out 100,000 bpd.

Ethylene Plastique Normandie will build a 15,000-tons-per-year polyethylene plant at Mont in the Lacq area of Southwestern France.

Allied Chemical Corp. plans to build a phthalic anhydride plant near Los Angeles. It should be on stream by late 1961 or early 1962.

Humble Oil & Refining Co. is planning to expand its oxo chemicals facilities. A 50 percent increase of the oxo chemical capacity at Baton Rouge, La., has been completed, raising the capacity of the refinery unit there to 90 million pounds per year. Building sites have not been selected as yet.

Shell Oil Co. is ready to make a further investment of $56 million in its Argentine operation. Shell already has about $84 million invested in Argentina, including $28 million earmarked for developing its oil refinery operation in Buenos Aires.

The Ohio Oil Co. will refine Libyan oil in Spain if the Spanish government permits them to build a refinery on the Northern Coast of Spain. The refinery would have a capacity of 25,000 bpd. The actual site is still under discussion.

British American Oil Co., Ltd., has long-range plans for a Nova Scotia refinery. Construction begins this year, with first deliveries due to begin next spring. The completion of the refinery proper may follow in the late 1960s.

Golden Eagle Refining Co. of Canada will build a 5,000-bpd refinery at St. John's, Nfld. It will be the first refinery in the province.

1*

*1 — that's right, *just one.* It's the only one of its kind because it was tailor made by Nelson for a major utility company for a specific purpose. It is, however, a good example of Nelson's "Controlled Power Package" which includes motor control centers, low voltage switchgear, high voltage starters, supervisory and special control, and other equipment in a single weatherproof structure, all interwired, ready to hook up to line and load.

This approach means important savings because Nelson takes on the detailed engineering required for coordination and interconnection, and also eliminates the necessity of engineering a separate building. You spend your money where it counts—on the electrical equipment.

This new approach to customer service again confirms the fact that Nelson is

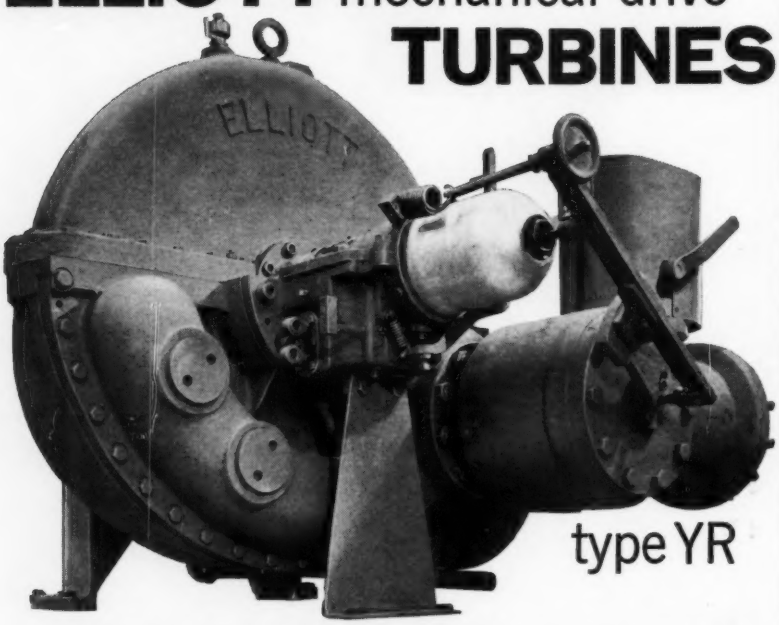
BIG ENOUGH TO PERFORM
SMALL ENOUGH TO CARE

Be sure to let your Nelson representative figure your next job. You will find him listed in the Yellow Pages of major city telephone directories.

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA
P. O. BOX 5385 NATIONAL 7-5530

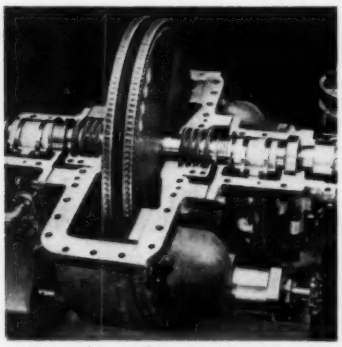
For more data on advertised products, use Readers' Service Cards, last page.

ELLIOTT mechanical drive TURBINES

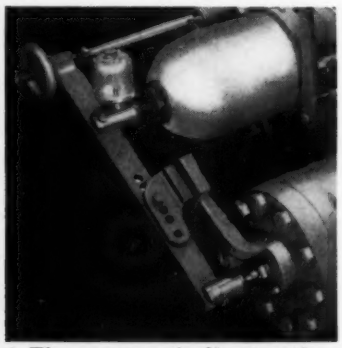


type YR

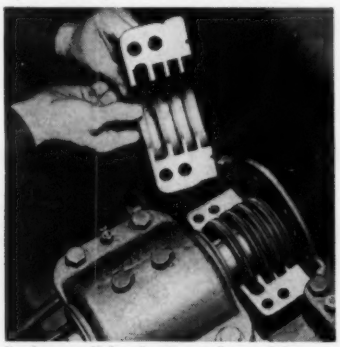
These features mean long life, easy operation



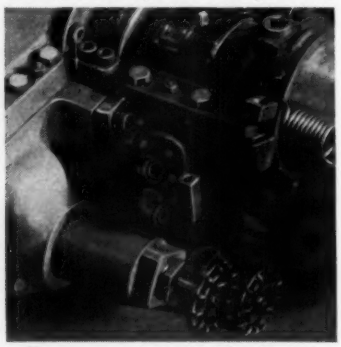
1. Smooth and dependable operation at all operating temperatures is assured by the precise alignment of the dynamically balanced shaft.



2. The governor is direct-acting, simple and weather-proof. Separate trip gives over-speed protection. Easily reset against line pressure.



3. Accessible shaft-seals and bearings simplify maintenance and inspection. Covers are readily removable without disturbing the casing.



4. Economy at partial loads is secured by the steam-saving hand valve with pilot, which can be opened against full steam pressure.

ELLIOTT Company
JEANNETTE, PENNA.

HO-2

Building . . .

Goodyear Tire & Rubber Co. will build a multimillion-dollar plant for the production of polyisoprene and polybutadiene. The new plant will be near Mobil Oil's Beaumont, Texas, refinery and is expected to be in operation within one year.

The Distillers Co. has entered into an agreement with the French firm Ugilor to build a plant for making acrylonitrile from propylene and ammonia. Ugilor can use Distillers' know-how and patents to build the plant.

Shell Oil Co. of Canada, Ltd., began construction on a hydrodesulfurizer at its Montreal East refinery in July. Completion is slated for December 1960.

Shell Oil Co. will build an $18-million ammonium phosphate plant at Safi, Morocco. The plant will have an annual capacity of 100,000 tons.

Shell Oil Co. is ready to go ahead with with a $10-million refinery in El Salvador to process Venezuelan crude for the Central American common market. The plant is to go into operation in 16 months in the Acajutla area, where Esso is also considering a refinery.

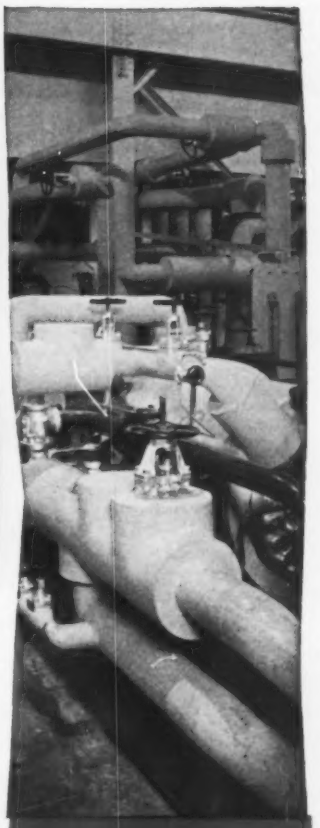
Imperial Oil, Ltd., will install a 32,000 bpd hydrofiner at its Sarnia, Ont., refinery to treat furnace oils. Existing equipment at Sarnia will be used for part of the unit, which will cost about $1 million.

Crown Zellerbach Corp. will manufacture dimethyl sulfide, methyl mercaptan and dimethyl sulfoxide at a new $1.7 million plant in Bogalusa, La.

Continental Oil Co. is building a $1.2 million refinery at Grand Chenier, La.

Use readers' service postcard, page 259, for more information on advertised products

Complete control
of temperatures with
PABCO
PRECISION-MOLDED
CALTEMP
a Calcium Silicate
Insulation



Name your temperature. A performance-proved Pabco pipe or block insulation will maintain it at economical levels up to 1900° F. With Pabco Caltemp, 85% Magnesia, or Prasco Insulations, heat losses are reduced to an absolute minimum . . . finest performance assured. For data on technical advantages, case histories, or engineering consultation . . . write . . . or contact one of Pabco's insulation engineers.

PABCO INDUSTRIAL INSULATIONS DIVISION

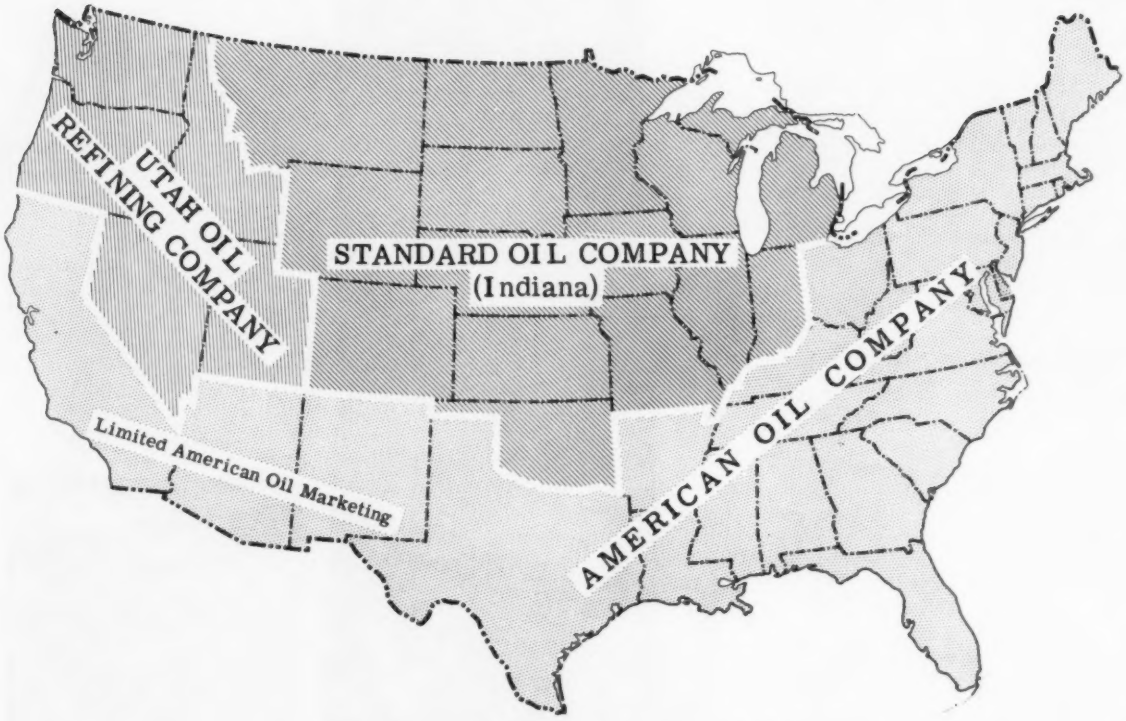
Fibreboard Paper Products Corporation • San Francisco 19 • Chicago 54 • Houston 4 • New York 16 • Los Angeles

INSULATION GUIDE

Temperature	Recommended Pabco Insulation
to 550° F.	85% Magnesia pipe covering + block + cement
to 1200° F.	Caltemp pipe covering + block + cement
to 1600° F.	Prasco 15 C pipe covering + block + cement
to 1900° F.	Prasco 19 C block

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening...



Map shows marketing areas before reorganization

All Indiana Standard's Operations To Be Included Under American Oil

Plans for an extensive corporate reorganization, effective, Jan. 1, 1961, subject to Internal Revenue Service clearance and to stockholder approval, has been announced by Standard Oil Co. (Indiana). Chairman Frank O. Prior and John E. Swearingen president, told stockholders in a letter "the purpose of the plan is the increased profitability of your company."

Prior and Swearingen said the reorganization will accomplish the following:

• Make Standard Oil (Indiana) exclusively a parent company concerned with broad management policy and with the coordination of subsidiaries that deal with all aspects of the oil business. The parent company will have no direct operating assets such as it now has in the Midwest.

• Combine all product refining, transportation, and marketing operations and assets of Standard and its wholly owned subsidiaries, Utah Oil Refining Co. and The American Oil Co., in a single company with unified management and generally with common trademarks and brands. This company will be The American Oil Co. L. W. Moore, now president of American Oil, will continue as president and chief executive officer. The new operating organization will use the American Oil name and related brands and trademarks, Prior and Swearingen said.

The proposed reorganization will be submitted to stockholders at a special meeting to be held probably in late September.

Present directors of the parent company, Standard Oil Co. (Indiana), who will continue as members of Standard's board are Swearingen, Dwight F. Benton, S. A. Montgomery,

NEED TUBING?

Specify TAILORED TUBING!

Made by a specialty mill with 33 years' experience tailoring quality seamless steel tubing to meet the most rigid specifications!

PRESSURE TUBING

TAILORED TUBING for continuous service under high pressures and temperatures.

Specifications:

ASTM	Grade	Analysis
A-53		Carbon steel
A-106		Medium carbon steel
A-333	C	1022 steel
	3	2315
	5	2512
A-335	P1	Carbon, ½% Moly.
	P2	½% Chrome, ½% Moly.
	P3	1¼% Chrome, ¾% Moly.
	P3b	2% Chrome, ½% Moly.
	P5	5% Chrome, ½% Moly.
	P5c	5% Chrome, ½% Moly. with Titanium
	P7	7% Chrome, ½% Moly.
	P9	9% Chrome, 1% Moly.
	P11	1¼% Chrome, ½% Moly.
	P12	1% Chrome, ½% Moly.
	P21	3% Chrome, 1% Moly.
	P22	2¼% Chrome, 1% Moly.

Sizes: 3/16" to 3" O.D., including standard I.P.S. sizes ⅛", to 2½" inclusive.

Wall thicknesses in an extra wide range, including Schedules: 40, 80, 160 Cold Drawn, and Hot Finished, Seamless pipe.

MECHANICAL TUBING

Machining parts with a hole? Use TAILORED TUBING to simplify fabrication, save time and material.

Available in many shapes (square, hexagonal, etc.) with O.D. from 3/16" to 3½".

Carbon Steel: Standard A.I.S.I. from grade designation C-1008 to C-1070 inclusive.

Alloy Steels: including all A.I.S.I. Open Hearth and Electric Furnace Steels; Haynes Alloy 25, Hastelloy C, X, R 235 and Multimet. But not including stainless, and E-50100, E-51100 and 9200 series.

Resulphurized Steel: In grades C-1118, C-1137 and C-1141.

Can be furnished cold drawn, normalized or any special anneals. Our superior annealing equipment assures meeting specifications with absolute minimum decarburization.

OIL-COUNTRY TUBING

Highest quality TAILORED TUBING for maximum dependability and outstanding service.

Grades: J-55, N-80, P-105 and higher.

Sizes: All the macaroni sizes, ¾", 1", 1¼", 1½", and 2" I.P.S.

Lengths: All standard length Ranges.

Facilities to full length normalize and straighten.

AIRCRAFT TUBING

This sturdy TAILORED TUBING is supplied in round, oval, square, rectangular and other shapes to your specifications.

Specification	Analysis	
MIL-T-5066	1025	Steel
MIL-T-6732	8630	
MIL-T-6733	8735	
MIL-T-6735	4135	
MIL-T-6736	4130	
AMS-5050	1010	
AMS-5075	1025	
AMS-6360	4130	
AMS-6365	4135	
AMS-6530	8630	Magnaflux Quality Steel
AMS-6535	8735	
AMS-6274	8620	
AMS-6281	8630	
AMS-6282	8735	
AMS-6283	8735	
AMS-6323	8740	
AMS-6371	4130	
AMS-6372	4135	
AMS-6381	4140	
AMS-6415	4340	

DECARBURIZATION

With the most versatile annealing and heat treating equipment in use today, Michigan Seamless can supply cold worked, normalized, stress-relieved and soft-annealed tubing for any end use, with decarburization normally less than half allowed by standard specifications.

We will quote and guarantee material to special government specification number MIL-T-6736A insofar as depth of decarburization is concerned.

CONDENSER, HEAT EXCHANGER, AND BOILER TUBES

Now, for the first time plain or integral fin U-tubes from one source! Almost all grades of TAILORED TUBING below are also available as integral fin tube and all can be U-bent to your specifications. Bi-metal tubing also available.

ASTM	Grade	Analysis
A-83		Low carbon steel
A-106		Medium carbon steel
A-161		Low carbon steel
A-179		Low carbon steel
A-192		Low carbon steel
A-210		Medium carbon steel
A-334	C	1022 Steel*
A-161	T1	Carbon, ½% Moly.
A-199	T3b	2% Chrome, ½% Moly.*
	T4	2½% Chrome, ½% Moly.*
	T5	5% Chrome, ½% Moly.*
	T7	7% Chrome, ½% Moly.
	T9	9% Chrome, 1% Moly.
	T11	1¼% Chrome, ½% Moly.*
	T21	3% Chrome, 1% Moly.
	T22	2¼% Chrome, 1% Moly.*
A-200	T3b	2% Chrome, ½% Moly.
	T4	2½% Chrome, ½% Moly.
	T5	5% Chrome, ½% Moly.
	T7	7% Chrome, ½% Moly.
	T9	9% Chrome, 1% Moly.
	T11	1¼% Chrome, ½% Moly.
	T21	3% Chrome, 1% Moly.
	T22	2¼% Chrome, 1% Moly.
A-209	T1	Carbon, ½% Moly.
	T1a	Carbon, ½% Moly.
	T1b	Carbon, ½% Moly.
A-213	T3b	2% Chrome, ½% Moly.*
	T5	5% Chrome, ½% Moly.*
	T5c	5% Chrome, ½% Moly. with Titanium
	T7	7% Chrome, ½% Moly.
	T9	9% Chrome, 1% Moly.
	T11	1¼% Chrome, ½% Moly.*
	T12	1% Chrome, ½% Moly.*
	T17	1% Chrome Vanadium
	T21	3% Chrome, 1% Moly.
	T22	2¼% Chrome, 1% Moly.*
A-334	3	2315 Steel*
	5	2512 Steel

*Integral fin tube available.

Sizes: 3/16" to 1" O. D., with wall thicknesses varying from very light to extra heavy. Integral fin tube available in 5/8" to 1" O. D. inclusive.

MICHIGAN SEAMLESS TUBE COMPANY

SOUTH LYON, MICHIGAN

A SUBSIDIARY:

GULF STATES TUBE CORPORATION

ROSENBERG, TEXAS

Send your job specifications to us. We will tailor the tubing to do your job. For more details write for full catalog.

TAILORED TUBING by Michigan Seamless Tube Company Gulf States Tube Corporation

STRONG is the word for **Centrifugally Cast** Pipe

. . . and the alloying is selected so that you will get high resistance to corrosion or high resistance to extreme heat or high resistance to both, as you require.

Centrifugally Cast Pipe has been a major DURALOY item since 1933 when we pioneered such high alloy castings in this country. Standard pipe production is in the following classification:

Outside Diameter	Minimum Wall	Length
2½" to 3"	1/4"	88" maximum
3" to 6" Inclusive	5/16"	110" maximum
Over 6" to 12" Inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" Inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" Inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" Inclusive	1/2"	88" maximum
Over 24" to 32" Inclusive	5/8"	80" maximum

RESISTANT is the word for **Chrome-Nickel** Alloying

The strength of Centrifugally Cast Pipe comes largely from the exceptionally uniform dense grain structure.

If you require a gas or liquid pipe line or a process tube requirement calling for high strength plus high resistance to corrosion and/or temperatures in the piping, DURALOY Centrifugally Cast Pipe will meet your specifications with complete satisfaction. This is the record of our castings in industry for many, many years.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Happenings . . .

David Graham, Robert C. Gunness, Jacob Blaustein, Homer J. Livingston, George V. Myers, Lawrence A. Kimpton, J. Howell Turner, and Merwin Bristol.

Officers of the parent company will include: President and chief executive officer, Swearingen, now parent company president; executive vice presidents, Gunness and Myers, now parent company executive vice presidents; vice president, Benton, now parent company vice president of sales; vice president, Montgomery, now parent company vice president of manufacturing; and financial vice president, Graham, now parent company financial vice president.

The office of chairman of the board will be discontinued on the retirement August 25 of Frank O. Prior, as previously announced. F. Cushing Smith, J. C. Ducommun, and William H. Miller will resign as directors of Standard and will become directors of American. American's board also will include Moore, Herman L. Boyle, Richard J. Farrel, John E. Kasch, Winston S. Peeler, and Philip C. White.

The officers of American Oil will include: President and chief executive officer, Moore, now president of American Oil; executive vice president, Smith, now parent company director and general manager of supply and transportation; vice president, Ducommun, now parent company director and general manager of manufacturing; and vice president, Miller, now parent company director and general manager of sales.

Moore, Dr. Kasch, and Peeler are now on American's board. Boyle, Farrell, and Dr. White are Standard Oil executives. For American, Dr. Kasch will be general manager of supply and transportation; Peeler, general manager of employe and public relations; Boyle, general manager of administration; Farrell, general counsel; and Dr. White, general manager of research and development.

Headquarters of both companies will be in Chicago. Standard Oil is now headquartered in Chicago, American Oil in New York, and Utah Oil Refining in Salt Lake City.

For more data on advertised products, use Readers' Service Cards, last page.

BLUEPRINT FOR PROFITS

from Steel...Oil...Chemicals

IN steel, petroleum and chemicals, profits begin with plant design. A profitable plant must be designed and built to operate efficiently now and for many years ahead—must have the built-in flexibility to meet future conditions. It must produce at rock-bottom operating cost and require minimum maintenance.

If that is the kind of plant you need call in McKee. You'll find McKee engineers get things done—done right and on time. That's the result of many years of world-wide experience on projects like yours. McKee will convert your plant *cost* into profit-earning *investment* at the earliest date—give your profit column a head start.

McKee Building, Cleveland Headquarters

ARTHUR G. McKEE & COMPANY
2300 Chester Avenue • Cleveland 1, Ohio

OFFICES IN: CLEVELAND
NEW YORK • WASHINGTON
UNION, N.J. • HOUSTON, TEX.
TORONTO: ARTHUR G. McKEE & COMPANY OF CANADA, LTD.
ENGLAND: McKEE HEAD WRIGHTSON LTD. (PETROLEUM & CHEMICAL PLANTS OVERSEAS)
HEAD, WRIGHTSON & COMPANY, LTD. (BRITISH REPRESENTATIVES OF THE McKEE METALS DIVISION.)

McKEE ENGINEERING
AND CONSTRUCTION SERVICES

Performance makes the world of difference

Fig. 6003—Steel gate valve for 600 W.P. Outside screw rising stem and yoke. Bolted flanged bonnet. Flanged ends.

Fig. 3061A—Steel horizontal swing check valve for 300 W.P. Heavily bolted flanged cap. Full unimpeded flow through when wide open.

Fig. 3058—Carbon steel, screwed end lubricated plug valve. ASA 300 pounds. Screwed gland type, wrench operated.

Fig. 2207G — Semi-steel, flanged end, lubricated plug valve for 200 pounds W.O.G. Bolted gland type. Worm gear operated.

In Powell's complete line of valves are STEEL valves for handling fluids in refineries, petrochemical plants and petroleum storage facilities all over the world.

For 100 years Powell valves have served the vital lifelines of the oil industry. Today, the Powell line includes all types of steel, bronze, iron and corrosion resistant valves in sizes to meet every flow control requirement of the wide-spread petroleum world.

Powell can quickly supply all your valve needs and help solve your valve problems. Contact your nearby Powell distributor. (There's one in all major cities.) Or write directly to the Wm. Powell Company.

Powell . . . world's largest family of valves

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

Happenings . . .

No Significant Reduction In Import Level Says Hope

The allocation of petroleum imports for the second half of this year as announced by the Department of Interior, reveals no significant reduction in the level of imports into the United States, Alvin C. Hope, IPAA president, said. Imports of crude oil, unfinished and finished oils, other than residual fuel oil, because of an expected seasonal decline in petroleum demand in Districts 1-4, will be reduced about 25,000 bpd in that area. Imports into District 5 are expected to increase about 47,000 bpd in the second half of this year. Residual fuel oil imports, including those exempt from control, for the third quarter of this year will be about 400,000 bpd, approximately the same level as actual imports in the third quarter of 1959.

Failure to reduce petroleum imports substantially for the next six months is most discouraging, reports Hope. In the light of continuing declines in exploration and development activities and an accelerating weakness in crude oil prices, it was logical to expect that imports would be reduced, Hope stated. The purpose of the mandatory program was to insure a strong, healthy expanding domestic oil producing industry. This goal of the program, under present import levels, is not being met, he added.

"I am firmly convinced that in the light of existing domestic oil industry conditions, the level of imports will have to be reduced if the mandatory oil import program is to meet its objectives."

Natural Gas Output For April Up 11% Over Last Year

The daily average production of natural gas liquids in April was 11 percent above April 1959, the Bureau of Mines, United States Department of the Interior, reported. The daily average production of liquefied gases at refineries was 8 million gallons, 1 percent above April 1959.

Ethane-ethylene production in April was 11 percent above April 1959. The daily average demand for liquefied gases for fuel and chemical uses increased 6 percent from April 1959. Stocks of liquefied gases excluding ethane totaled 711 million gallons, an increase of 149 million gallons during April 1960. Underground stocks of liquefied gases totaled 509 million gallons, a decline of 1 million gallons from a year ago.

The daily average demand for natural gasoline was 11.6 million gallons, an increase of 13 percent from April 1959.

GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAY Tool Company

GRAYLOC SALES DIVISION

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 05

For more data on advertised products, use Readers' Service Cards, last page.

Happenings . . .

Dr. Eyring To Deliver Fifth E. P. Schoch Lecture

"Rate Processes" will be the subject of Dr. Henry Eyring, of the University of Utah, as he delivers the fifth lecture for the E. P. Schoch Series to be held Oct. 14 and 15 at The University of Texas. Dr. Eyring will give a relatively brief but comprehensive discussion of the modern theory of rate processes, together with an evaluation of future trends in the field.

Brazil Refineries Expected To Meet Needs By End of '60

Brazil is expected to have an adequate refining capacity by the end of 1960. Idalio Sardenberg, president of Petroleo Brasileiro S. A., said that Brazil's demand at the present rests at 220,000 bpd, while its present refining capacity amounts to 140,000 bpd. The total capacity of three of the nation's refineries stands as follows: Mataripe refinery, Bahia, 15,000 bpd; Duque de Caxias refinery, Rio, 90,000 bpd; and the Cubatao plant, 20,000 bpd. Refineries not included in Petroleo Brasileiro have a total capacity of 40,000 bpd.

ARCCO
The New
ARCCO-ANUBIS
RD-B (Dry-Air)
GAS
GRAVITOMETER
FULLY
COMPENSATES
FOR BAROMETRIC
PRESSURE
CHANGES
With the new ARCCO-Anubis RD-B Gas Gravitometer you get a highly accurate record of the specific gravity of gases... *fully compensated for changes in barometric pressure* as well as changes in temperature and humidity. It employs two columns; one for gas, one for "dry air." The difference in weight between the "dry air" and the gas in these two columns is measured and recorded in terms of specific gravity. A floating lever attached to the unit of a 6" aneroid barometer assures that the recorded gravity will always be corrected for barometric pressure changes.
ARCCO-ANUBIS GAS GRAVITOMETERS
★ For Recording
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MANUFACTURERS OF PRECISION INSTRUMENTS
SEND FOR BULLETIN NO. 101-R4

Independent Refiner Group Launches Budget, Program

An enlarged budget and expanded program of activity has been adopted by the Independent Refiners' Association of America in the following directions:

To insure continuation "and extension" of present methods of oil imports control which "partially offset" impact of foreign oil on domestic inland refiners.

To deal with "artificial" economic forces which interfere with normal, fair competitive practices and lead to unreasonably narrow refining margins.

To seek out and publicize marketing practices which threaten independent refiners.

To bring to attention of oil producers the close relationship of their welfare to that of independent refiners, and to work toward joint action with producers on matters of common interest.

M. H. Robineau, Frontier Refining, president of IRAA, said certain current trends in industry must be reversed or "the ultimate end . . . will be the extinction of the independent refiner and the consolidation of monopolistic forces."

API to Expand Its Abstracting Service

An expansion will take place in the Central Abstracting Service of the American Petroleum Institute starting January 1, provided sufficient interest is generated in the oil industry, Frank M. Porter, API president, has announced. This expanded service would cover domestic and foreign patents as well as exploration and production scientific publications, domestic and foreign.

Since its establishment in 1954, the CAS has provided basic coverage on petroleum refining literature. More than 140 sources from all over the world are regularly scanned. Over 12,000 pertinent abstracts are published annually in bulletin form for the current information of technical people in petroleum companies, and in the form of classified cards for library reference use.

If the plans for expanded coverage are justified by orders from oil companies, the API service will then issue three bulletins of abstracts each week. Cost of the services would be paid by subscribers to the bulletins. Inquiries on the service should be directed to W. T. Gunn, American Petroleum Institute, 1271 Avenue of the Americas, New York 20.

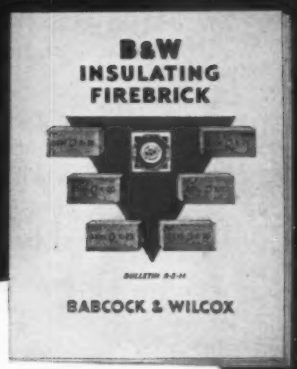
Congressman Shipley Says Import Program Has Failed

A complete review of the level of imports under the U.S. government's mandatory oil import program has been called for by Congressman George Shipley, Illinois. Congressman Shipley has charged that the mandatory program

For more data on advertised products, use Readers' Service Cards, last page.

Why B&W IFB for Oil Heater Linings ?

- Lightest weight
- Simplified construction
- High hot load strength
- Lower conductivity
- Lower heat storage
- Better process control



The light weight of B&W Insulating Firebrick provides savings in capital investment in several different ways. The light weight of B&W IFB permits thinner wall constructions of equivalent insulating value. These thinner, lighter walls mean real savings in structural steel and concrete. Construction is further simplified because B&W IFB's high hot load strength makes possible higher unsupported walls without deformation at furnace operating temperatures. In addition B&W IFB can be cut and shaped with ordinary wood working tools, simplifying field installation.

The light weight of B&W Insulating Firebrick also provides the greatest insulation. Thus, they save more fuel.

Light weight also means lower heat storage. B&W IFB protect you against burn-out of expensive alloy tubing in the event of forced shutdown. B&W IFB respond faster to changes in firing rate, too, assuring you of more positive process control.

**Write for Bulletin R-2-H giving more data on B&W Insulating Firebrick.*

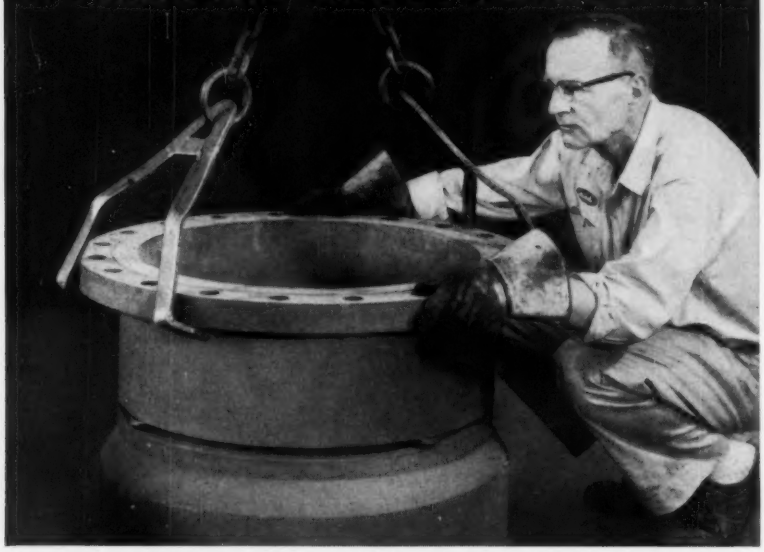
B&W

THE BABCOCK & WILCOX COMPANY

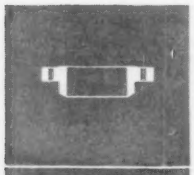
REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

LENAPE OFFERS A NEW CONCEPT IN PRESSURE VESSEL CONNECTIONS

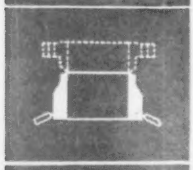


Now—by combining a Lenape ASA bolt flange which is a short seamless welding neck and your choice of three seamless bodies, you get optimum reinforcement, design flexibility and economy.



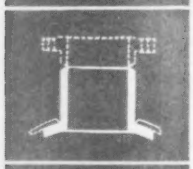
SPECIAL ASA BOLT FLANGE

Simple, low cost attachment, with easier alignment and orientation. You can choose different materials for body and flange, as well as length with unmatched economy in lengths over 12″.



SEAMLESS CYLINDER EXTENSION

Superior to pipe or rolled plate. No seams. Built-in reinforcement. Choice of length and thickness.



TYPE C INTERNAL REINFORCING NOZZLE

Separate bolt flange makes more efficient internal reinforcement possible.

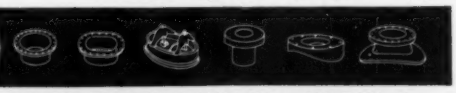
TYPE D EXTERNAL REINFORCING NOZZLE

External attachment with massive reinforcement.

All of these are available in 300 to 900 lb. ASA standards.

Full details and specifications are given in the new 96-page Lenape Catalog. Write for your copy.

LENAPE PRESSURE VESSEL CONNECTIONS



LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PA.
RED MAN PRODUCTS

Happenings . . .

which was established in March of last year has failed to bring about a reduction in the level of petroleum imports. "Instead," he said, the program "only stabilized a rate that was already excessive."

He emphasized that throughout the tri-state area of Illinois, Indiana and Kentucky the crude price structure is deteriorating, oil development activity is decreasing and as a result there is economic uncertainty and generally depressed conditions throughout. He stated that in the tri-state area the price of crude oil has declined from $3.15 a barrel in October 1957 to $2.85 a barrel at present. "The last cut, only recently, was for 15 cents a barrel," he said.

So long as foreign oil continues to take a great share of the domestic market, the domestic oil producer's ability to recover his capital will be diminished, Congressman Shipley said.

Socony Mobil Oil Forms New Chemical Division

A new operating division, Mobil Chemical Co., has been formed to carry on the U.S. and foreign petrochemical activities for Socony Mobil Oil Co. Socony has named Paul V. Keyser, Jr., a senior vice president, to be the division's president. At the same time, Keyser becomes executive vice president of the parent company. His corporate planning duties at Socony will be taken over by George F. James, director and senior vice president of finance. Both are Socony directors.

Mobil Chemical, Socony said, will begin forming its staff immediately. Included under the new set-up will be Socony paint products and Socony's petroleum additives and specialized chemical products businesses.

The new division will be responsible for petrochemicals produced at or near Socony Mobil facilities, including a high-purity ethylene plant being built at Beaumont, Texas.

IPAA Head Foresees Problem for Oil Industry

A five-year period of nearly-constant crude demand, plus only "moderate" increases expected in the next five years mean the oil industry and conservation agencies face the serious problem of "adjusting operations and activities," says Minor S. Jameson, Jr., executive vice president of IPAA. During the next five years, he said, crude demand is expected to increase at an annual rate of about 150,000 bpd each year. This is

For more data on advertised products, use Readers' Service Cards, last page.

SPECIAL INSULATION PROBLEMS?

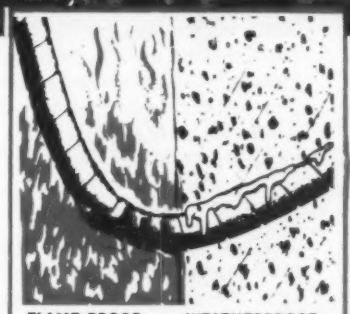
WRAP 'EM UP FAST!

tops for personnel protection and instrument line insulation

You save with Insutape when you have instrument lines that need quick, low cost, effective insulating or wherever close clearances make ordinary insulations difficult to apply.

Insutape also contributes substantial savings where insulation is to be removed and reapplied. Withstands the ravages of intense heat or vibration.

This insulation of a thousand uses is made of long-fibered asbestos rovings, completely enclosed in a tubular woven asbestos jacket, furnished either plain or with Neoprene-impregnated weatherproof jacket. It's tough, resistant to abrasion, moisture, oil and grease... quick and easy to apply. YOU CAN DO IT FASTER WITH INSUTAPE!



FLAME PROOF **WEATHERPROOF**

Insutape's woven asbestos jacket, heavily coated with Neoprene makes it a rugged pipe protector and a highly efficient insulation even under extreme conditions. A snug fit that will properly weatherproof instrument lines and also provide personnel protection. Quick, tight, easy application.

Write today for complete information and engineering data

INSUTAPE

The wrap-on insulation of a thousand uses

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• UNIBESTOS, Amosite Asbestos Pipe Covering and Block • Calcium Silicate Pipe Covering and Block • 85% Magnesia Pipe Covering and Block • Mineral Fiber Block • Wrap-On Insulation • Lace-On Insulation • Turbine Blankets • Insulating and Finishing Cements • Asbestos Textiles • Packing and Gasketing.

UNION ASBESTOS AND RUBBER COMPANY • FIBROUS PRODUCTS DIVISION

DEPT. 263, Bloomington, Illinois

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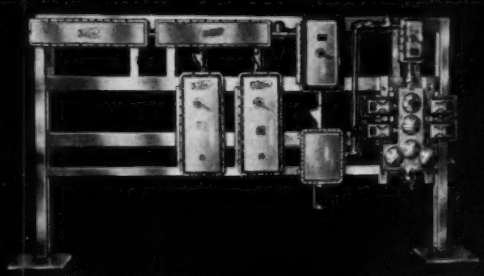
Killark custom-made switch racks...

designed and built to meet your needs...exactly



Your worries are over from the moment you choose Killark custom-made switch racks because Killark provides a complete service — design to assembly. First, Killark prepares and submits a preliminary blueprint of the entire unit, drawn to your specifications. After approval, the switch rack is assembled, wired, and sealed *at the factory* by Killark workers with experience and equipment to do the job right. You receive a switch rack ready to install.

The two racks shown are examples of the type of custom-made units Killark can provide. Each has been made to meet the users exact specifications, and is completely pre-wired and pre-sealed. Killark's rust-proof, non-sparking *aluminum* enclosures have been used throughout the assemblies to give added years of trouble-free performance.

You get these extras when you order Killark custom-made racks:

Services of expert Killark engineers • One supplier for all components • Dependable Killark aluminum enclosures • Fast delivery • Easy installation.

Racks for outdoor or indoor, hazardous or non-hazardous locations. Write for complete literature.

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Vandeventer and Easton Aves. • St. Louis 13, Mo.

Sales Representatives and Warehouse Stocks in Principal Cities

6021

Killark Supplies Everything But the Current!

Happenings . . .

about half the rate of growth that occurred in the 10-year period following World War II, he said. In years past, Jameson said, state conservation programs and industry operations have been geared to a steadily-increasing demand for crude oil. Exploration, development and production activities have been based on supplying a growing market, he added. Jameson said "1960 will be the fifth consecutive year when the total requirement for domestic and imported crude oil will average approximately 8 million bpd. No like situation has confronted state conservation agencies and the industry in the past quarter of a century. This occurred despite an increase of about 180,000 bpd each year in product demand. Factors responsible for this condition are the maladjustment of inventories, the upgrading of crude oil, the increase in the output of natural gas liquids and the increase in imports of products other than residual fuel oil."

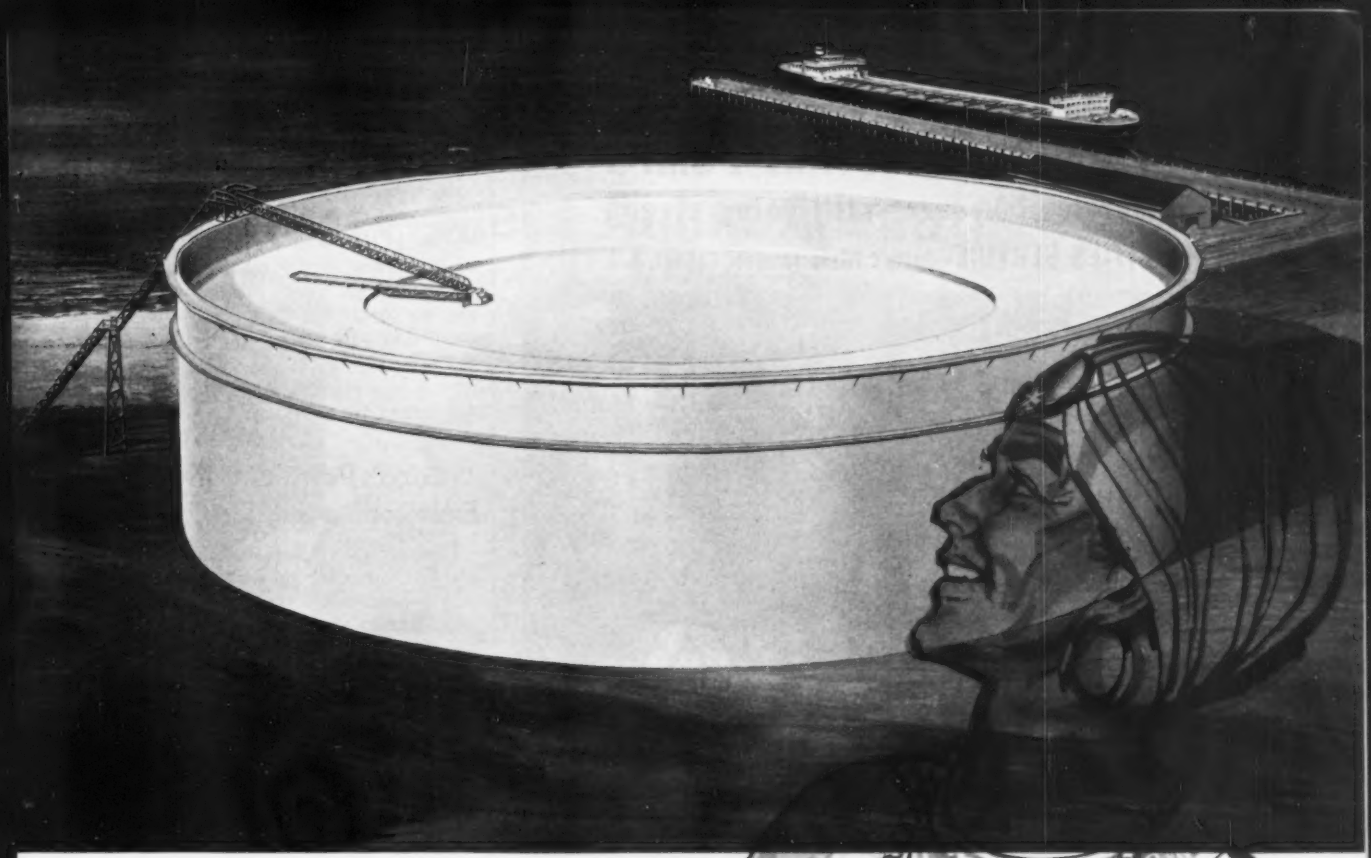
IPAA Calls For Restraint, Foresees Demand Increase

"Continued restraint" on the part of U.S. petroleum refiners during the remainder of the third quarter has been called for by the Independent Petroleum Association of America. In its monthly Supply and Demand Outlook the national oil organization recognized that much progress had been made in correcting excessive refined product inventories during the second quarter. However, the Association pointed out that at the end of June total inventories were about 14 million barrels higher than the adequate stock levels forecast by the IPAA last April.

The Association said total petroleum inventories at the end of June were estimated at 776 million barrels, or 41 million barrels less than the excessive volume in storage on June 30, 1959. In cautioning the industry, the IPAA stated that refinery runs during the last two weeks of June averaged 8,260,000 bpd as compared to an IPAA forecast of 7,800,000 bpd as an adequate level for the third quarter. "Continuation of runs at this level through October could offset much of the improvement in refined product inventories which was accomplished in the second quarter," the Association stated.

The Outlook stated that the total demand for petroleum, including domestic consumption and exports, for the next three months, August through October, is expected to average 9,400,000 bpd, an increase of 400,000 bpd or 4.4 percent above the same period last year. This compares with a total demand averaging 9,250,000 during the second quarter which was 233,000 bpd, or 2.6 percent

For more data on advertised products, use Readers' Service Cards, last page.



CB&I creates a giant in Kuwait!

CB&I is building the world's largest floating roof tank for American Independent Oil Company, in Mena Abdulla, Kuwait, Arabian Gulf. The tank—to be constructed by Chicago Bridge Limited—will measure 260 ft. in diameter and 64 ft. in height. It's a task even Aladdin and the mystic genie of the lamp would have considered most difficult. No problem, however, for CB&I's world wide *Coordinated Services* in engineering, fabrication and erection.

Within the tank shell, a Horton pontoon floating roof equipped with a Horton fabric seal will ride the surface of the product. By eliminating vapor space in the tank, it will reduce evaporation loss, decrease corrosion and minimize fire hazard.

Big job? Tough job? CB&I "can do."

CHICAGO BRIDGE & IRON COMPANY

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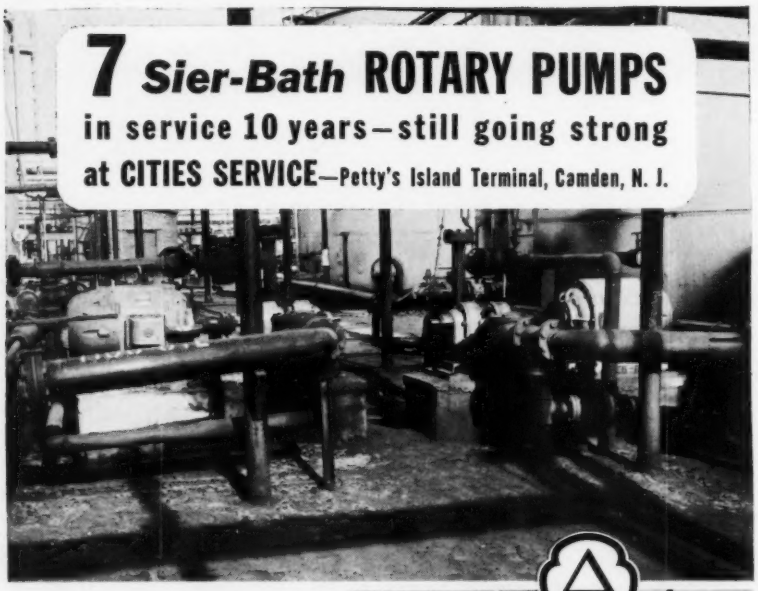
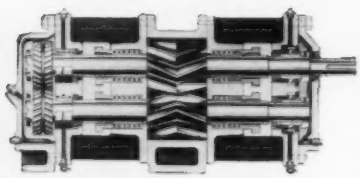
OFFICES AND SUBSIDIARIES IN PRINCIPAL CITIES THROUGHOUT THE WORLD



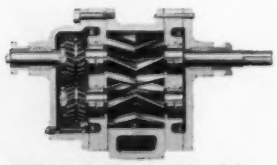
7 Sier-Bath ROTARY PUMPS
in service 10 years—still going strong
at CITIES SERVICE—Petty's Island Terminal, Camden, N. J.

● Operating one to three hours daily since 1950 in lube oil transfer and tank truck loading service, these Sier-Bath GEAREX Rotary Pumps continue giving excellent service. The pumps deliver 300 gpm. of lube oil ranging from 500 to 3,000 SSU at 30 to 115° F., with flooded suction against discharge pressure of 75 psig. Also in operation, are several Sier-Bath Screw Pumps handling 500 gpm. of lube oil stock having 10,000 SSU at 130° F., discharging at 90 psig with flooded suction.

Sier-Bath "Gearex" Pumps



EXTERNAL GEAR & BEARING TYPE
for non-lubricating liquids



INTERNAL GEAR & BEARING TYPE
for lubricating liquids

Sier-Bath "Gearex" Pumps provide positive displacement, pulseless flow . . . quiet, vibrationless operation. Direct-connected up to 1800 RPM, they require no reduction gears. For high volumetric efficiency and long life there is no rotor-to-rotor or rotor-to-casing contact. Low pressure on stuffing boxes provides easy servicing.

Horizontal or vertical models to handle 32 to 500,000 SSU, 1 to 550 GPM at 250 PSI for viscous liquids, 50 PSI for water. Corrosion-resistant alloys, steam-jacketed bodies, water-cooled bearings, other adaptations to meet individual needs. See "Yellow Pages" for your local Sier-Bath Pump Representative or send for Bulletin G-2. *Sier-Bath Gear & Pump Co., Inc., 926 Hudson Blvd., North Bergen, N. J.*

Sier-Bath ROTARY PUMPS

Screw Pumps | Gearex® Pumps | Hydrex® Pumps

Founded 1905 | Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings | Member A.G.M.A.

Happenings . . .

above the second quarter of 1959.

To meet the expected demand and still maintain total inventories approximately in line with the IPAA forecast, the total new supply required of crude oil, natural gas liquids and imports during the next three months would be about 9,450,000 bpd.

The market for U. S. crude oil is expected to average 6,900,000 bpd during the August-October period.

Mexico's Petroleum Industry Experiences Big Growth

Growth of the petroleum industry in Mexico is stepping up with construction of a petrochemical center at the Minatitlan refinery, Southeast of Mexico City, and a continued increase in the production of liquid petroleum from natural gas, according to reports from Florencio Lara Sosa of the Instituto Mexicano de Ingenieros Quimicos.

The petrochemical center will be built near reforming plants of Petroleos Mexicanos, which processes highly napthenic crudes. Lara Sosa said that chlorine and sulphuric acid are to be produced in quantity in the same area, along with natural gas in unlimited amounts.

The gas processing industry will gradually deal entirely in raw gas except the methane and just sufficient heavier components to leave a residue of gas meeting heat unit requirements of gas purchasers, John E. Walke, Dallas, and Charles E. Webber, Philadelphia, Sun Oil Co. engineers, said. Some 14 billion gallons of liquid petroleum are now produced from natural gas annually, they said.

Refrigeration processing and light oil absorption will play major roles in technical advancements in liquid hydrocarbon recovery. Also new absorbents with higher and more selective capacity will appear, Walke and Webber said.

Texaco's Port Arthur Plant Sets New Safety Record

A new world's record in safety for petroleum refineries was set by Texaco Inc.'s Port Arthur plant by having 7,647,716 plus man-hours of operating time without a lost-time injury. The previous highest total was 7,506,711 man-hours, the record achieved by Esso Standard Oil Co. at its Baton Rouge refinery, according to the American Petroleum Institute.

All former safety marks at the Texaco plant, including the previous high of 3,802,845 man-hours reached in April

CHECKUP on your Control Valves... CHECKOFF these Annin Advantages*

*Any other source might give you a few... but with Annin you get them all!

MINIMUM number of parts per complete valve.

OVER 60,000 successful case histories of split body valve applications.

POSITIONING ACCURACY guaranteed, .001 inch per inch of stroke.

CONSTANT INSTRUMENT signal sensitivity throughout signal range.

COMPLETE INTERCHANGEABILITY of any Domotor valve to on-off pneumatic control, pneumatic hydraulic, electro hydraulic, electro pneumatic or manual actuator.

ENGINEERED FOR MANUAL control with any of the above automatic actuators, if desired, at minimum cost.

SIMPLIFIED ADDITION of high speed booster units to any pneumatic positioning actuator.

ADAPTABILITY of bellows seal, doolseal or plain extension to any standard valve.

BODY SIZES from ¼" up.

COMPLETE LINE of body ratings: 600—1500—2500 lbs. ASA; special 10,000 and 60,000 psig design, temp. —450°F to 1600°F.

CONVERSION FROM globe body to angle body construction with only one additional part.

ADAPTABILITY TO 3-WAY Valve Construction with minimum parts and cost.

MINIMUM COST for change from soft seat construction to hard seat, or vice versa.

First in a series of checklists on Annin features.

Annin **VALVES**

THE ANNIN COMPANY
1040 South Vail Avenue
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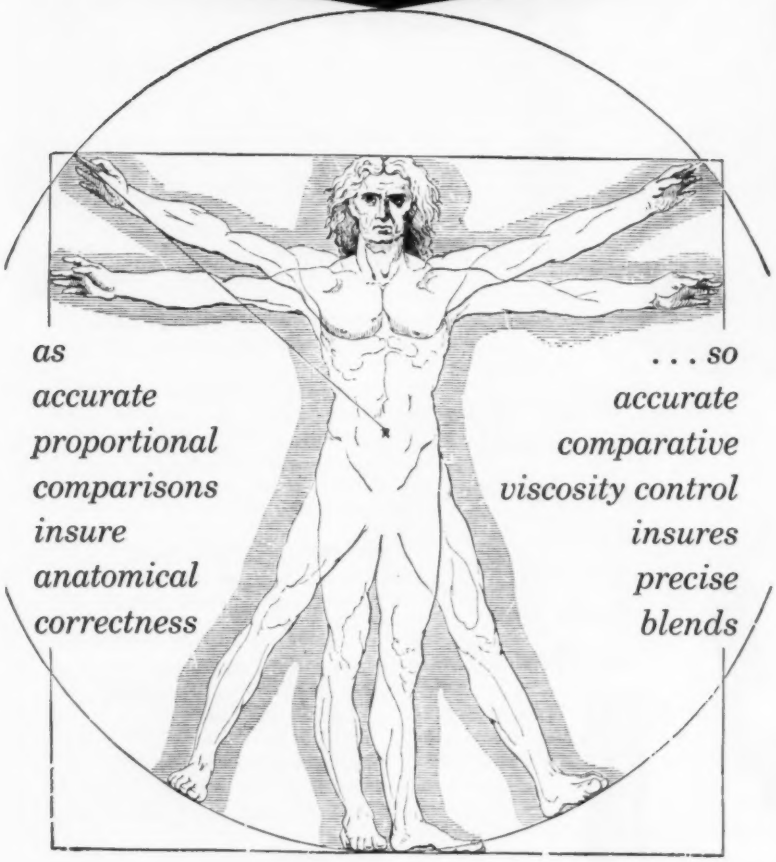
WHAT HAS THIS TO DO WITH VISCOSITY?



as accurate proportional comparisons insure anatomical correctness

. . . so accurate comparative viscosity control insures precise blends

and you can make them better with a

Bendix* Viscomparator

Accurate blending of petroleum products to a specification viscosity can be controlled continuously and automatically. The viscosity of the process fluid is compared with that of a reference sample at operating temperatures. Wide-range temperature compensation is inherent in the Bendix Viscomparator's design. Its sensing element withstands up to 650° F. (343° C.) and 1,000 psi.

For complete information about this surest, most modern method of controlling viscosity, write Dept. W-8

*REG. U. S. PAT. OFF.

Cincinnati Division
3130 Wasson Road · Cincinnati, Ohio

THE Bendix CORPORATION

Export Sales and Service: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario

Happenings . . .

1958, have been more than doubled. E. W. McNealy, Port Arthur plant manager, said, "It represents a great team effort in which every employe is keenly aware of safety and accident prevention. Without this attitude and the individual cooperative effort of our employes, the world's best mark could not have been achieved." McNealy added that the accident prevention program at the plant has been given special emphasis in the past ten years.

New Petrochemical Division Set Up By Cities Service

A new Petrochemical Development Division to coordinate all petrochemical activities of the Cities Service Co. has been established, Burl S. Watson, chairman of the parent Cities Service Co., said. As a part of this move, 55 scientists and technicians have been transferred from Petroleum Chemicals, Inc., a subsidiary at Lake Charles, La., to Cities Service Research and Development Co. This group will be the core of the company's petrochemical laboratory at Lake Charles.

At the same time, a central Planning Division has been established in the New York offices of Cities Service Research and Development Co. to coordinate and direct the long-range research and product development activities of all Cities Service petroleum and natural gas operating subsidiaries.

Pure Oil Has Revised Personnel System

Pure Oil Co. has disclosed a revised system of personnel progression and titles, giving formal recognition to the contributions of scientists and technical specialists in non-administrative positions at its research center. Professional personnel at the center can progress on a merit basis to positions of increased responsibility by one of three routes: the supervisory or administrative route, the scientific way, or the technical specialist route.

Petroleum Products Prices Pickup After May Low

During recent weeks, prices of petroleum products have made a substantial recovery from a 5½-year low reached at the end of May. A pickup in the demand for products and con-

Electro-Hydraulic Valve Actuators

by **GPE Controls** offer the simplest, most compact, lowest-cost way to operate control valves from an electric signal. Model 698 shown positions 1¼" double-seated valve at 1000 p.s.i. pressure drop, with input signal ranges of 1-5, 4-20, or 10-50 ma. Completely self-contained. Easy, low-cost installation. Position repeatability within .002". Automatic locking with power failure simplifies start-up of process. Division I construction for hazardous service is standard. Other models available for heavier duty.

GPE Controls | A GENERAL PRECISION COMPANY

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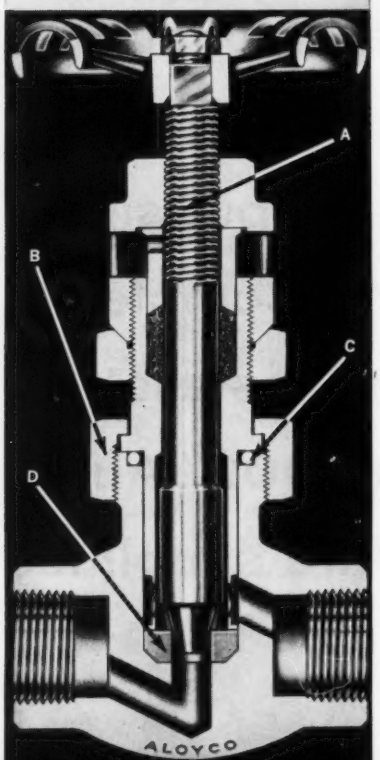
Stainless Steel* Aloyco Needle Valve eliminates leakage and galling!



A. OUTSIDE STEM THREADS are away from corrosive area prevent galling.
B. UNION BONNET provides extra strength and easy disassembly.
C. TEFLON O-RING provides tough, leak-proof seal.
D. TEFLON SEATS are pressure-tight, dependable, won't gall. Renewable.

*Alloys available: 18-8S, 18-8SMo, Aloyco 20

This #62 Stainless Steel needle valve has proved itself for 10 years in many types of severe corrosive service. It is particularly suitable for sensitive control of flow as in metering, or sampling for process plant, laboratory or pilot plant use. For more facts write: Alloy Steel Products Company, 1303 West Elizabeth Ave., Linden, New Jersey.
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Longer Lasting ALOYCO VALVES
TRY IN CORROSIVE SERVICE

ALLOY STEEL PRODUCTS COMPANY

Happenings . . .

siderable progress in correcting inventories have started a reversal in the downward trend in oil prices which had fallen to the lowest level since 1954.

Refinery prices for the four major products now average 20 cents per barrel above the May level, but are still lower than in the early months of last year and far below 1957 prices. However, there is a trend toward a restoration of adequate prices, according to IPAA.

Oklahoma-Pate Division Is Result of Merger

A new division has been created by the Humble Oil & Refining Co. as a result of the merging of Oklahoma Oil Co. and Pate Oil Co. into the Oklahoma-Pate Division. Oklahoma and Pate have been marketers of petroleum products in the upper Midwest for more than 20 years. Oklahoma has about 400 stations in Illinois, Indiana, and parts of Iowa and Kentucky. Pate operates about 200 stations in Wisconsin.

This merger completes the consolidation of the domestic operating affiliates of Standard Oil Co. (New Jersey) into one company under unified management.

Venezuelan Oil to Be Based on Sound Economy

Venezuelan businessmen have been assured that the country's new national oil company will be established on sound economic basis and that it will operate in "peaceful coexistence" with private oil industry. President Romulo Betancourt spoke at closing session of the Federation of Chambers of Commerce and Production. He said Venezuelan Petroleum Corp. won't compete with private companies, and promised that it won't show losses such as those of government airlines.

Betancourt's declarations followed adoption by the assembly of an oil-policy resolution implying doubts as to the advisability of setting up a national oil company. The resolution recommended that activation of the company be postponed "until a more propitious opportunity" in case certain objectives couldn't be met.

Western Oil And Gas Urges Stronger Smog Law

Strengthening of Rule 62, the smog law limiting fuel oil burning, has been urged by the Western Oil and Gas Association, Los Angeles. This would keep pollution levels down to state health

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PULSCO SUCTION MUTE®
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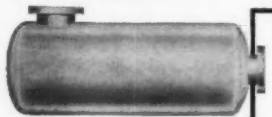

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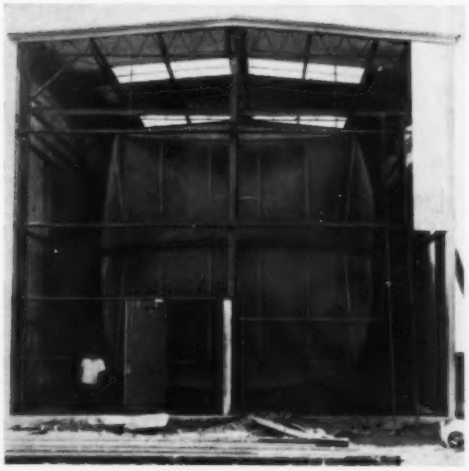

Stop vapor loss with this air-tight, self-contained, completely closed system.

Now—with a low-cost Breather Balloon installed in new or modified storage systems, you can capture the vapors that might otherwise be lost during the storage or transfer of volatile liquids. Reeves-Vulcan Breather Balloons require no skilled labor to install, no high priced housing . . . cost practically nothing to maintain.

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Just 1 Universal Die Head and 2 Sets of Dies
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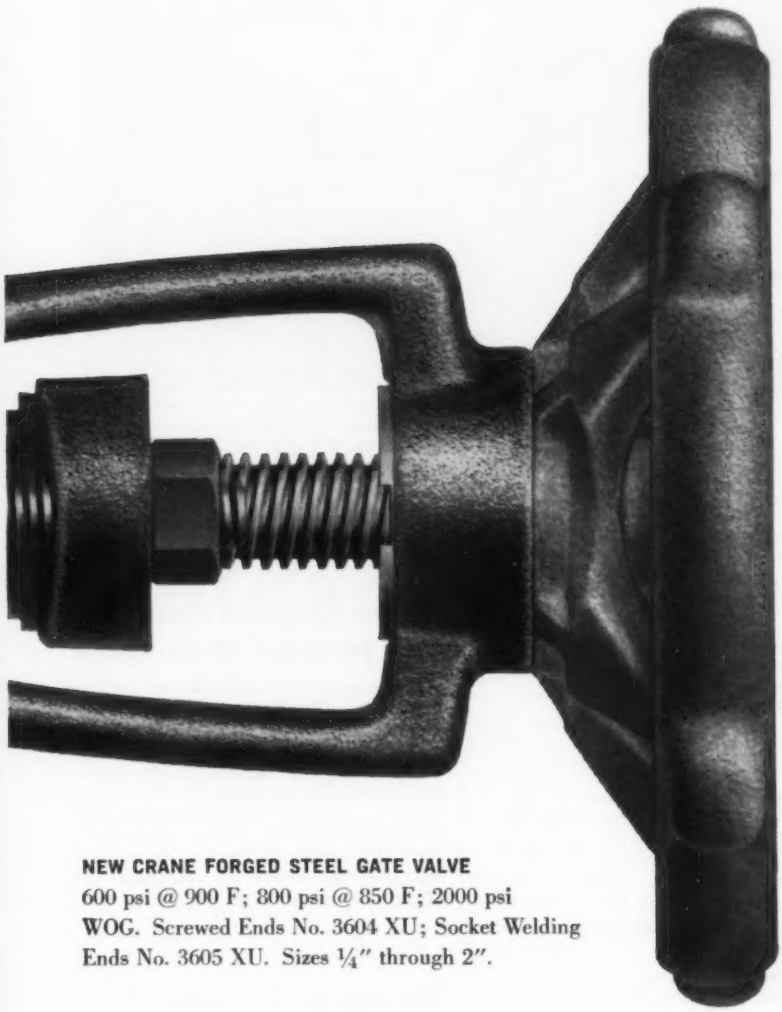

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Bondstrand is a corrosion-resistant, high strength, rigid pipe made of glass filaments bonded in chemically inert synthetic resins. It is capable of withstanding high pressure and the corrosive attack of many salt, acid, and alkaline solutions. The outside surface is equally resistant because the pipe is made entirely of corrosion-proof materials. No painting or maintenance is necessary.

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Bondstrand is now available in sizes from 2" through 8" with all necessary couplings and fittings. Larger sizes available on special order.

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Happenings . . .

standards and extend it to be effective all year-round. The rule now bans the burning of fuel oil of more than 0.5 percent sulfur content from May through October each year.

In addition, industry has been voluntarily switching to natural gas throughout the rest of the year, when the Air Pollution Control officer forecasts smoggy weather. Howard G. Vesper, association president, pointed out that the California State Department of Public Health adopted standards of air purity on Dec. 4, 1959, and that studies had been under way since that time to determine the effectiveness of Rule 62.

July-September Demand Put at 9.3 Million BPD

Demand for petroleum in the United States during the July-September period should average 9.3 million bpd, representing an increase of about 300,000 bpd or 3.3 percent, compared with a like year-earlier period, says IPAA. Total new supply needed from imports and domestic production during June was expected to average about 9.4 million bpd and actual crude production about 6.8 million bpd for June. If imports average 1.6 million bpd and natural gas liquids production 900,000 bpd, the market for domestic crude would increase slightly to about 7 million bpd during the third quarter.

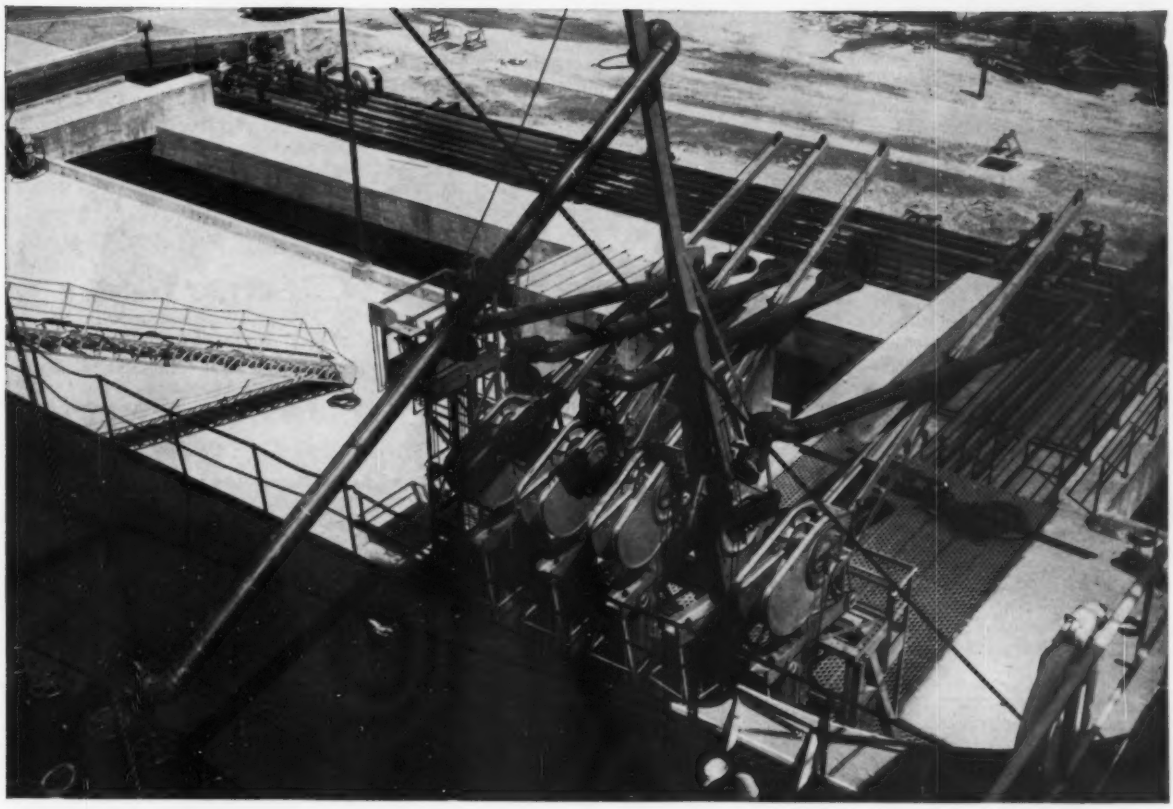
Texaco Revamps Research And Technical Department

Expenditures on research and technical activities by Texaco, Inc., have increased substantially during the past 10 years, and this year will total nearly $23 million, L. C. Kemp, Jr., vice president of the Research and Technical Department, stated. The department has been reorganized to provide some flexibility in growth and to permit increasingly rapid commercial application of new processes and products, Kemp said.

'Plastics vs. Corrosion' Is Theme of SPE Meeting

"Plastics vs. Corrosion" will be the theme of the Society of Plastics Engineers' regional technical conference set for October 5 at the Mark Hopkins Hotel in San Francisco. The meeting discussion will center on the use of plastics in combatting corrosion.

The conference will be supplemented on October 6 and 7 by a regional meet-



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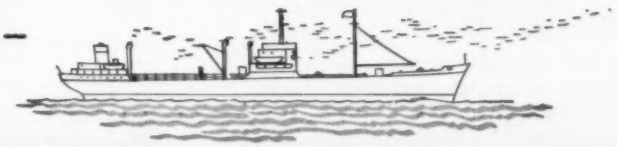

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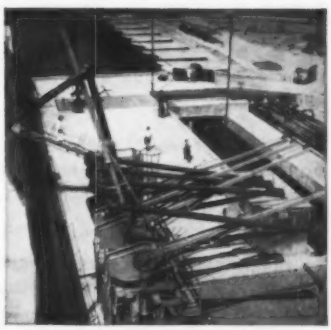

Where once a crew of seven men labored for 30 minutes to hook up a rubber line, now one man operating hydraulic controls can swing a Chiksan Loading Arm aboard, for hook up, in less than a minute.

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Happenings . . .

ing of the National Association of Corrosion Engineers at the Sheraton-Palace Hotel in San Francisco.

Cities Service Domestic Runs 7.5% Below Last Year's

Domestic refinery runs for this year, to May 7, for Cities Service Co., have averaged 7.5 percent below the same period last year, while runs for the industry as a whole have increased, Burl S. Watson, chairman of board, stated. The company's current inventories of crude oil and the four principal refined products are substantially lower than at this time last year, Watson said.

Crude Imports Had Slight Drop in April

U.S. imports of crude and products into the United States dropped slightly in April to 1,865,000 bpd from 1.88 million bpd in March, but were higher than the 1.43 million bpd average of April 1959. Crude imports averaged 1 million bpd in April, compared with 920,000 bpd in March and 789,000 bpd in April 1959. Residual imports averaged 636,000 bpd in April; 821,000 bpd in March and 489,000 bpd in April 1959.

- Changing Times -

Australia had to import all 90 million barrels of crude oil and refined products it used in 1959, William H. Spooner, minister of Ausralia's national development said. The bill came to $297 million, including almost $73 million for freight charges.

$5,100 has been granted the Colorado School of Mines by National Science Foundation for the school's computer center. Established in 1957, the center now has a digital and an analog computer.

A cash offer from Lobitos Oilfields has been accepted for all stock in Manchester Oil Refinery, Ltd., by 90 percent of Manchester's stockholders.

"Progress Through Instrumentation," is general theme for ISA Instrument-Automation Conference and Exhibit, Sept. 26-30. Conference is scheduled to begin at 10 a.m. Monday, Sept. 26.

U.S. Congress enacts Coal Research Act. Secretary of Interior Seaton states his department will establish office of coal research.

$6.1 million given to Cornell University on long-term contract for advanced research program. The University of Pennsylvania and Northwestern University along with Cornell have been selected to set up programs for expansion of basic research in science of materials, the Advanced Research Projects Agency, U. S. Department of Defense, reports.

India and Russia sign agreement for imports of kerosine and diesel oil. The imports, which will be channelled through Indian Oil Co., are expected to reach 1.5 million tons in 3½ years. First shipment to India scheduled in August.

Movement of Alberta crude to refineries is set at average of 313,979 bpd in August. Average in July was 354,259 bpd. September estimated average is 308,938 bpd. Expected average in October is 331,307 bpd.

Meetings Calendar

Sept.	
7– 9	**ISA, ASME, AIEE, IRE, AIChE,** Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass.
11–16	**California Institute of Technology,** Management Development Conference, Campus, Pasadena, Calif.
11–16	**American Chemical Society,** National Meeting, New York.
13–15	**ACS,** Chemical Exposition, Statler Hilton Hotel, New York.
14–15	**Western Petroleum Refiners Association,** Rocky Mountain Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyo.
14–16	**National Petroleum Association,** Annual Meeting, Hotel Traymore, Atlantic City.
–15	**Natural Gasoline Association of America,** Rocky Mountain Regional Meeting, The Palliser Hotel, Calgary, Alta., Canada.
15–16	**American Society of Mechanical Engineers,** Engineering Management Conference, Hotel Morrison, Chicago.
18–21	**ASME,** Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.
21–23	**ASME-AIEE,** Power Conference, Bellvue-Stratford Hotel, Philadelphia.
25–28	**American Institute of Chemical Engineers,** Meeting, Mayo Hotel, Tulsa.
25–28	**American Institute of Electrical Engineers,** Electrical Conference of the Petroleum Industry, Hotel Skirvin, Oklahoma City.
26–30	**American Welding Society,** National Fall Meeting, Hotel Penn-Sheraton, Pittsburgh.
26–30	**Instrument Society of America,** Fall Automation-Instrument Conference and Exhibit, Annual Meeting, New York Coliseum, New York.
Oct.	
6– 7	**National Association of Corrosion Engineers,** Annual Western Region Conference, Sheraton-Palace Hotel, San Francisco.
6– 8	**NACE,** Southeast Region Conference, Dinkler-Plaza Hotel, Atlanta, Ga.
9–12	**ASME,** Rubber and Plastics Conference, Lawrence Hotel, Erie, Pa.
10–11	**ASME-AIEE,** Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.
11–14	**NACE,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
13–14	**California Natural Gasoline Association,** Fall Meeting, Hotel Miramar, Santa Monica, Calif.
19–20	**NACE,** Conference, North Central Region, Pfister Hotel, Milwaukee.
25–28	**NACE,** South Central Region Conference, Mayo Hotel, Tulsa.
26–27	**WPRA,** Question and Answer Session on Refining Technology. Rufus Garrett Hotel, El Dorado, Ark.
–28	**NGAA,** Southern Regional Meeting, Carlton Hotel, Tyler, Texas.
–28	**AIChE,** South Texas Section Technical Meeting, Rice Hotel, Houston.
31– Nov. 2	**ISA, AIEE, IRE,** Conference, Electrical Techniques in Medicine and Biology.
Nov.	
14–16	**American Petroleum Institute,** Annual Meeting, Conrad Hilton, Palmer House, and Congress Hotels, Chicago.
–18	**NGAA,** Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo, Texas.
27– Dec. 2	**ASME,** Annual Meeting, Statler Hilton Hotel, New York.
Dec.	
4– 7	**AIChE** Meeting, Hotel Statler, Washington.
7–11	**NACE,** University of Illinois Corrosion Control Short Course, Urbana Campus.
12–14	**U.S. Public Health Service,** National Conference on Water Pollution. Sheraton Park Hotel, Washington, D.C.
Jan. 1961	
16–19	**ISA,** Conference & Exhibit, Winter Instrument-Automation, Sheraton-Jefferson Hotel, Kiel Auditorium, St. Louis, Mo.
–20	**NGAA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi, Texas.
Feb.	
–24	**NGAA,** South Louisiana Regional Meeting, Lafayette Petroleum Club, Lafayette, La.

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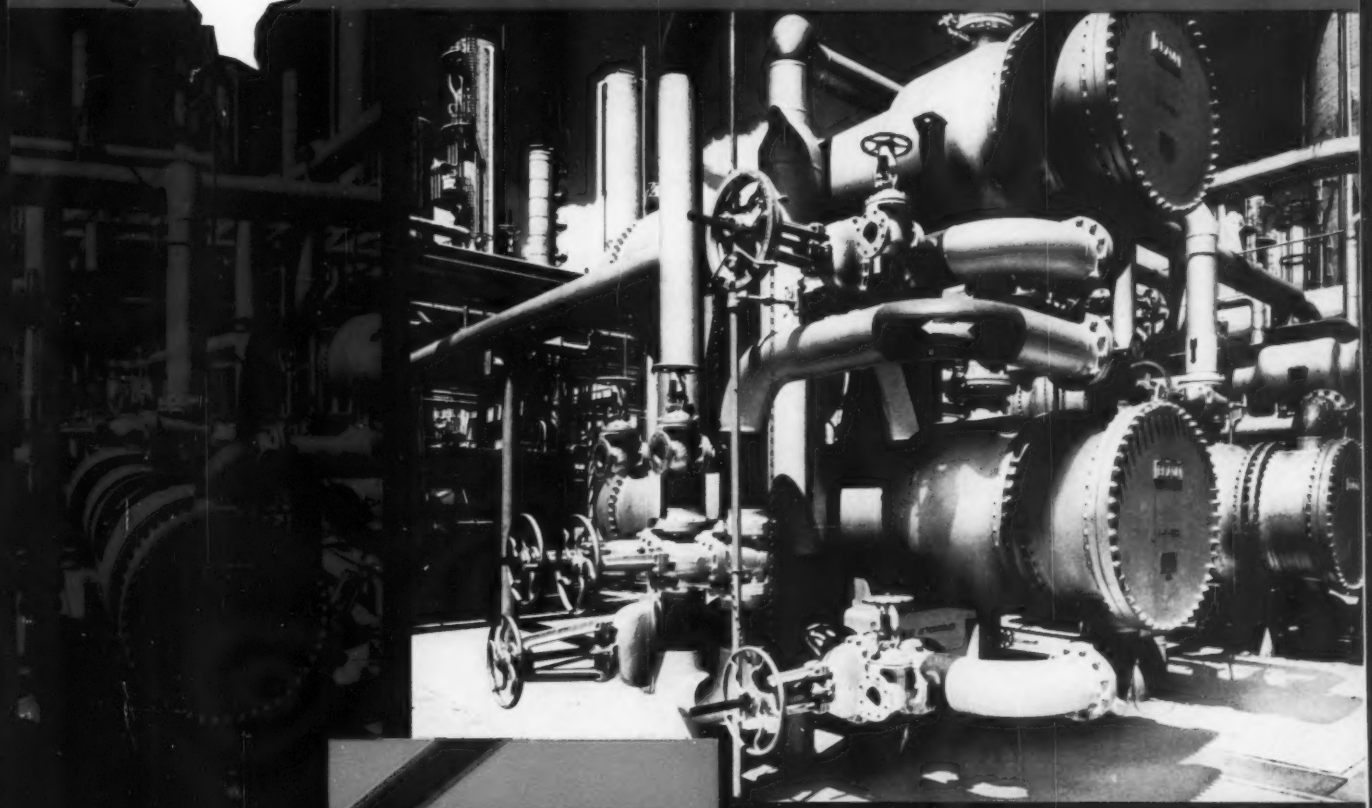

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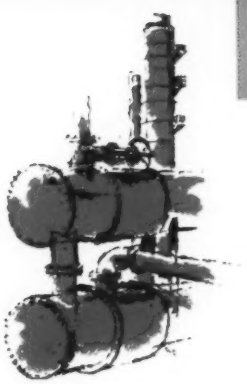

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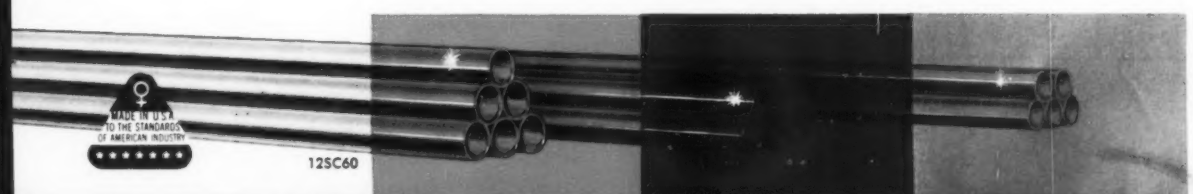

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Many college teachers are faced with this kind of decision year after year. In fact, many of them are virtually bombarded with tempting offers from business and industry. And each year many of them, dedicated but discouraged, leave the campus for jobs that pay fair, competitive salaries.

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Men In Industry...

Raymond D. McGranahan has been appointed president of Wilshire Oil Co., Los Angeles. He was formerly administrative vice president and coordinator of transportation for Gulf Oil Corp. He graduated from Allegheny college, Meadville, Pa., and did graduate work at the Harvard School of Graduate Business administration. He joined Gulf Oil in 1948 on the staff of the assistant to the president. He had been a vice president since 1954.

McGranahan

Lewis Gross has been named manager of research and development for Delhi-Taylor Oil Corp. He was formerly chief engineer of manufacturing. **Henry Warnke** has been appointed plant manager of the firm's Corpus Christi refinery. Warnke joined the company in 1941 and has been a plant chemist, engineer, assistant chief engineer and plant superintendent.

Carl G. Ries has been appointed manager of the Patent Division, Jefferson Chemical Company, Inc. He is a graduate in petroleum engineering from the University of Wyoming and has an LL.B. degree from George Washington University. He has been with Humble Oil & Refining Company, Houston, for the past six years.

B. A. Martin and R. B. Nesbitt have been promoted to senior chemical engineers in Humble Oil & Refining Co.'s Technical Division, Baytown, Texas, and **T. G. Lipscomb** to senior research chemical engineer in the Research and Development Division.

Peter John Sereda, Division of Building Research of the National Research Council of Canada, has received the Sam Tour Award at the 63rd annual meeting of the American Society for Testing Materials, Atlantic City, N. J. The award is given to the author or authors of a technical paper, published by the society, of outstanding merit in improvements and evaluation of corrosion testing methods. Sereda's paper was entitled, "Measurements of Surface Moisture," which was published in the ASTM Bulletin, February 1958.

Everard A. Elledge, chief project engineer for Stone & Webster Engineering Co., Boston, has been appointed manager, Stone & Webster Engineering (Holland) N. V., Amsterdam. **Donald F. Wishart,** former manager, has returned to Boston as consultant in the Chemical Division.

J. Q. Cope has been appointed a vice president of California Chemical Co. Cope was formerly a vice president of the California Research Corp. Since joining the Standard of California organization in 1931, Cope has held technical and management positions, including that of vice president in charge of chemicals research.

Paul E. Ditto has been named technical service manager, B. F. Goodrich-C. S. R. Chemicals Pty. Ltd., a chemical company recently established in Australia by B. F. Goodrich Chemical Co., Cleveland, and C. S. R. Chemicals Pty. Ltd., Sydney, Australia.

Frederick P. Glazier has joined Sun Oil Co. as special assistant in Research and Development Division. Glazier will be principal liaison for Sun with the automotive and aviation industries. He will also act as special assistant to **John G. Moxey, Jr.,** assistant director, motor products, in research and development.

F. B. Langreck, technical advisor to the general manager of Monsanto Chemical Co.'s Research and Engineering Division, and a Monsanto employe for 43 years, has been named an affiliate professor of chemical engineering at Washington University.

Wolfinger

Newsome

J. A. Newsome, Jr., and Paul F. Wolfinger have combined their talents to form the New Wolf Construction Co., Houston. Newsome is president of the firm and Wolfinger is executive vice president. Newsome, a graduate of Rice Institute, started his career with the Production Research Division of the Humble Oil & Refining Co. Since 1948, he has been associated with research and development of oil and gas equipment, installation of production facilities and industrial sales with Parks Engineering Co., the Parkersburg Rig & Reel Co. and Tellepsen Petro-Chem Constructors. Wolfinger, who worked with Manhattan Construction Co., Midwestern Constructors, Fulton Engineering, Carson-Wolf Corp. and Tellepsen Petro-Chem Constructors, is a graduate civil engineer of Oklahoma A & M College.

Joseph Gilbert has been named secretary and general manager of the Society of Automotive Engineers, a group concerned with engineering phases of ground, air, and space vehicles. Gilbert, SAE's assistant general manager since 1957, succeeds **John A. C. Warner,** who had held the post since 1930. Warner will continue on the SAE staff as an advisory consultant.

Gilbert

Dr. Lewis F. Hatch has been awarded a Fulbright grant to serve as lecturer at the University of Cairo. Hatch, a member of the university's chemistry faculty for 20 years, will serve as consultant in petrochemistry to the United Arab Republic's national research center in 1960-61. Hatch accepted the grant on request of the State Department to go to Egypt under a United States program of technical assistance to Middle Eastern countries.

John C. Fedoruk has been appointed technical director of Allied Chemical Co.'s General Chemical Division. He succeeds **Dr. Howard H. Hurmence,** who was named assistant director of research and development. Fedoruk, who has been assistant technical director for the past six years, has been with the division 19 years. He earlier served as manager of General Chemical's Development Laboratory, Baton Rouge, La., and as research chemist at its plant in North Claymont, Del.

William E. Lifson has been named associate director of Esso Research and Engineering Co.'s Products Research Division. He was an assistant director in the Products Research Division where he was responsible for motor lubricants and additives research.

W. D. Allison has been promoted to senior supervising engineer in the Technical Division, Humble Oil & Refining Co. He will continue to direct the work of the section responsible for new equipment studies, design, maintenance and lubrication engineering for refinery machinery. The section is also responsible for fire protection engineering and technical safety studies.

E. F. Battson, New York, has been elected president of Refineria Panama, S. A. He is a former director and vice president of Continental Oil Co. He has been general manager of petrochemical sales for Continental Oil since 1953.

Recorders of the future will have

Powerful Servomatic Motors in both TRANSCOPE® Pneumatic and Electronic Recorders give unprecedented accuracy of records . . .

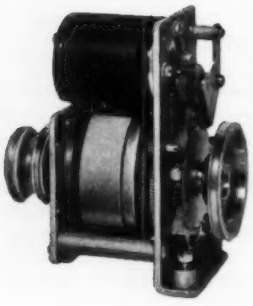
One of the reasons why the 90J (pneumatic) and 700J (electronic) recorders have become the most wanted miniature instruments is this exclusive Taylor feature . . . powerful Servomatic motors that give more precise pen positioning than ever before. Check these benefits:

- Threshold sensitivity of 0.1% to input signal.
- 150 times more power than bellows type used in conventional pneumatic recorders. Over 1,000 times the output power of galvanometer systems in electronic instruments.
- Unprecedented standards of accuracy—½ of 1% in standard instruments—¼ of 1% optional.
- 3 months' ink supply *mounted on the pen*—no capillary.
- Integral heavy duty process alarms in recorder cases . . . 2 per servo . . . up to 6 per recorder.
- No flimsy linkages and levers.
- Truly rectilinear chart—no curved time lines.

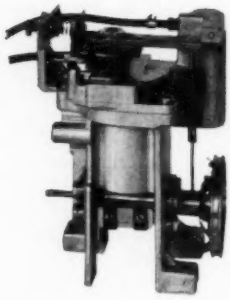
Servomatic motors also allow these optional features: alarm contacts; retransmitting potentiometer; function generation; digital output with encoder discs.

"Hunk of Brass" Test. Ask your Taylor Field Engineer to show you the 'Hunk of Brass' test — conclusive proof of the power of Servomatic motors to assure positive, precise positioning of the pen.

For full details of TRANSCOPE servo operated recorders and their many superior features, write for **Bulletin 98335** (electronic) or **Bulletin 98286** (pneumatic). Taylor Instrument Companies, Rochester, New York, and Toronto, Ontario.



700J (electronic) servo motor is 2 phase, size 15, 60 cycle, 117 volt—built to military specifications. Precision gearing couples the servo to a precise feed-back device with high torque.



90J (pneumatic) servo motor is essentially a power piston with a built-in positioner. Solid construction assures long, trouble-free life.

Taylor Instruments

Servo Power

TRANSCOPE 700J
ELECTRONIC
RECORDER

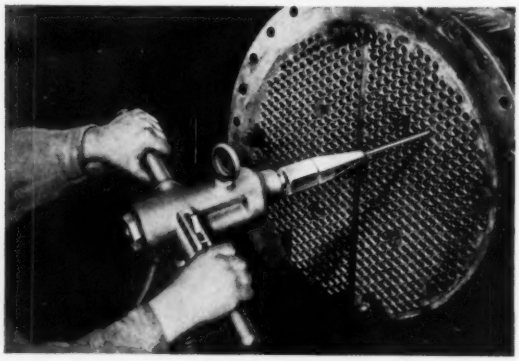
...Taylor has it NOW!

MEAN ACCURACY FIRST

For more data on advertised products, use Readers' Service Cards, last page.

KNOCK OUT SCALE
WITH
SUPER-POWERED
WILSON TUBE CLEANERS

Are your heat exchanger tubes completely fouled with scale buildup? Or, are you looking for that last vital inch of heat transfer efficiency? In either case, efficient, hard-working Wilson Tube Cleaners are the answer.



For heavy duty service, for example, use Wilson air driven Model TP 301 shown above. This super-powerful, 15 lb, light weight, scavenger-type tube cleaner drills and simultaneously flushes out deposits. It is suitable for vertical or horizontal use in straight tubes 3/8" ID to 2 7/8" ID and up to 40' long. Cleans rapidly and thoroughly, operating at high speed at 90 psi. Can run on pressure as low as 50 psi. Other Wilson Cleaners are available for every tube size.

WILSON SUPER-DUTY CARBIDE BITS

TYPE M BIT
An inserted two-lip Helix type for general use. 1 1/32" to 1 19/32" bit OD.

TYPE K BIT
A two-lip Helix type with adaptor for general use. 1 1/4" to 2 3/4" bit OD.

TUBE EXPANDERS— Wilson Models 41 and 44 Self-Feeding Tube Expanders are modern tube expanders for the *precision rolling* of condenser and heat exchanger tubes into heavy tube sheets. Ball Bearing Collar Type 1/2" OD to 2 1/2" OD • **Write for your free copy of Wilson Catalog 77-88. It's a mine of information on tube cleaning and tube expanding problems.**

Representatives in principal cities
THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N.Y.
Cable Address: "Tubeclean," New York

WILSON TW-899
BETTER TOOLS FOR BETTER WORK

Men . . .

William H. Fetter has been elected president of Texas City Refining, Inc. He held the position of vice president and general manager since coming to TCR in 1951. He succeeds **V. A. Fogg,** who was elected chairman of the board. Fetter has a degree in petroleum engineering from Penn State University, and is a registered engineer in the states of Texas and Pennsylvania. Other officers elected or re-elected were **W. T. Steele,** vice president and vice chairman of the board and **L. W. Robbie,** vice president of operations.

Fetter

Dr. John V. Clarke, Jr., has been named a research associate at Esso Research and Engineering Co. A chemist, Dr. Clarke is a member of the Products Research Division and directs his efforts to research on heavy fuels.

Robert F. Marschner and Philip Hill have been named assistant directors in the area of information and communications in the Research and Development Department for Standard Oil Co. (Indiana). Dr. Marschner will direct Standard's activities in supplying scientific information to the staff and reporting the results of research and development. Dr. Hill will supervise coordination between the research and development staff and the company's patent attorneys.

Dr. Chung Yu Shen, St. Louis, a research chemical engineer with Monsanto Chemical Co.'s Inorganic Chemicals Division, has been promoted to scientist. Shen's appointment will allow him more time to develop research programs in areas which are important to the division's chemistry, without devoting time to administrative duties.

Dr. Warren L. Jensen has been promoted to assistant manager of Continental Oil Co.'s Research and Development Department. Formerly director of Continental's petrochemical research, he will supervise activities of the petrochemical research, petroleum products, and research services divisions.

A. H. Hayes, senior assistant manager, Whiting refinery, Standard Oil Company (Indiana), has been appointed manager of the Planning Division in the Manufacturing Department at the Chicago general office. **R. G. Anderson,** superintendent of the Light Oils Division at the Whiting refinery, has been appointed an assistant manager at Whiting.

For more data on advertised products, use Readers' Service Cards, last page.

Quality control is a relentless task at J&L. Here a skilled metallographer examines steel structure through a modern photomicroscope.

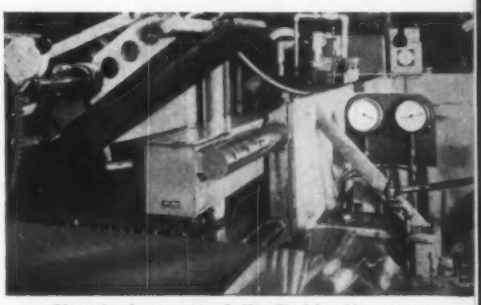
Be 100% Certain...Buy 100% Tested Pressure Tubing

J&L Electricweld pressure tubing is the finest carbon steel tubing available for heat exchanger, condenser, boiler, evaporator and other applications—yet shows savings of as much as 45% against seamless tubing.

J&L Electricweld pressure tubing provides the uniform outside diameter, wall thickness and concentricity that guarantee excellent heat transfer characteristics and fine surface quality. Its strength and ductility assure easy fabrication and installation.

J&L Electricweld pressure tubing is subjected to precise checks at every stage of production, from the basic steelmaking process until the tube is ready for shipment. This series of critical examinations on every length of tubing—inside and out—assure you of perfect field performance. Further details of Electricweld tubing and the economies it offers compared with seamless are available on request from J&L—creator and producer of *unmatched* Electricweld tubing.

J&L uses this latest type of electro-magnetic nondestructive tester to inspect both the inside and outside of Electricweld pressure tubing.



Dimensional accuracy of J&L Electricweld pressure tubing is determined long before fabrication. Shown here is an X-ray gauge control device which continuously measures the gauge of the sheet and strip steel.

This Steelmark identifies products made of steel. Place this mark on your products. And—look for it when you buy.

Steel

J&L STEEL

Jones & Laughlin Steel Corporation

ELECTRICWELD TUBE DIVISION • 3 GATEWAY CENTER, PITTSBURGH 30, PA.

How General Electric PRODUCT INNOVATION

ADDED VALUES

QUALITY CONTROL

Quality control influences every G.E. operation, from order receipt to shipment.

PRODUCT INNOVATION

Product research and development is advanced in all 98 G.E. laboratories.

APPLICATION ENGINEERING

Customer-oriented application engineers assist you with systems integration.

ANALYTICAL ENGINEERING

The latest tools of process analysis are available for studies of your problems.

INSTALLATION AND SERVICE ENGINEERING

Expert on-site assistance gives you smoother installation and earlier start-up.

SYSTEM CO-ORDINATION

G.E.'s systems experience focuses the full Company capabilities on your order.

NATION-WIDE SERVICE SHOPS

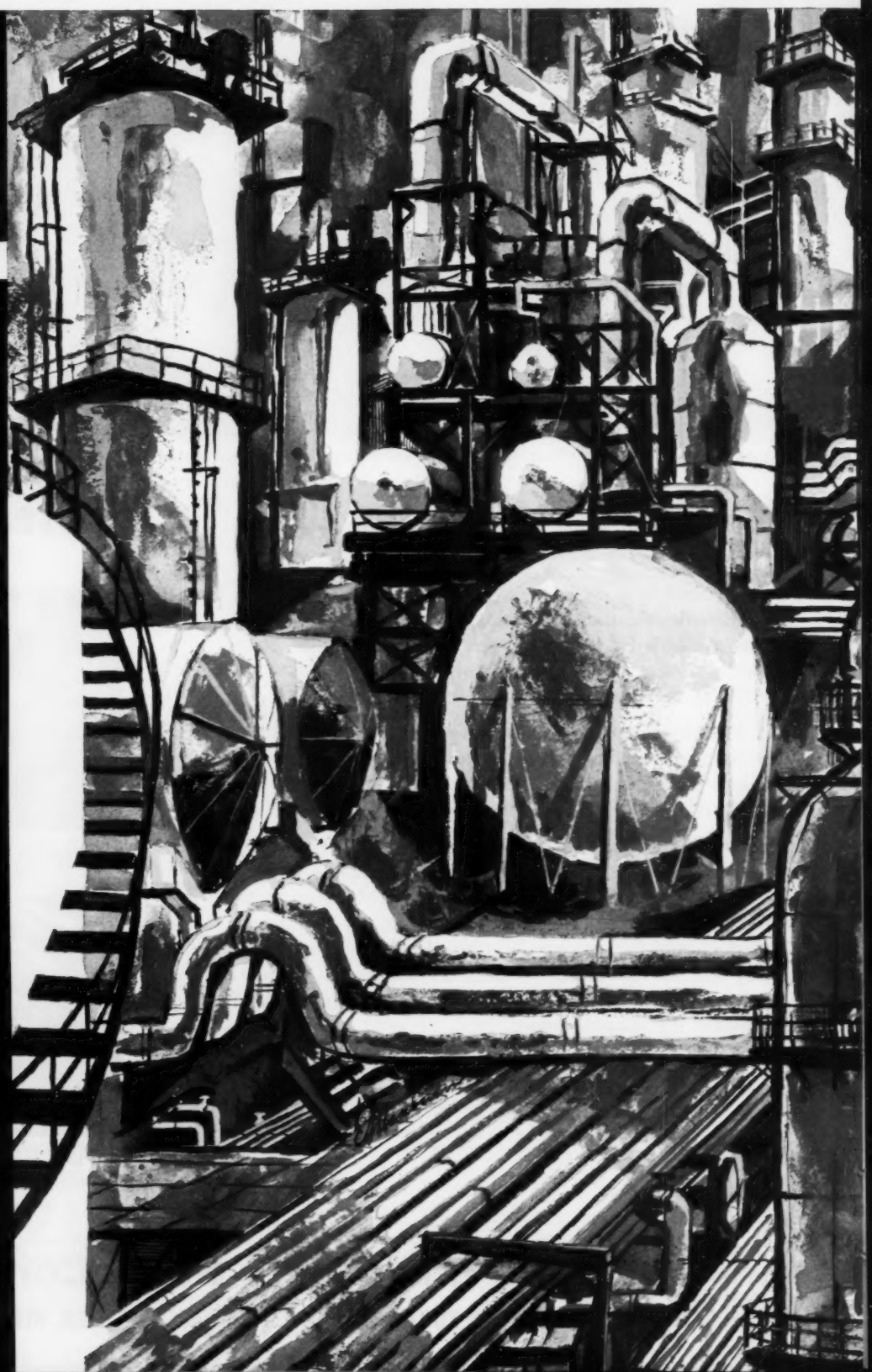
More than 50 G.E. Service Shops offer you 'round-the-clock maintenance service.

PROMPT DELIVERY

Accurate delivery cycles put your new G.E. equipment to work for you—on time.

VALUE ANALYSIS

Value Analysis gives you optimum combination of product value and economy.



helps give the petroleum and chemical industries

PROCESS FLEXIBILITY

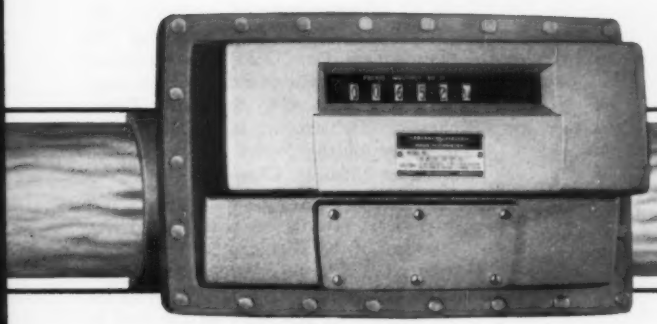
Recognizing your urgent needs for flexibility to meet fast-changing process requirements, General Electric is constantly developing more *versatile* products. General Electric investment in research and development, currently more than three times as much per sales dollar as the average for all industry, keeps G-E product versatility in step with your process requirements.

AN EXAMPLE OF GENERAL ELECTRIC PRODUCT INNOVATION is the new gyro-integrating true mass flowmeter. This versatile instrument continuously, accurately, and directly measures, *in pounds*, fluid streams over wide fluctuations in flow rate, density, pressure, temperature, and viscosity. The mass flowmeter eliminates the time-consuming—and sometimes erroneous—conversion of volume to weight. And *one* basic meter accurately measures a great number of industrial liquids and gases.

FOR MORE INFORMATION on G.E. product innovations that give your processes additional flexibility, call your local General Electric Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y. 651-01

Progress Is Our Most Important Product

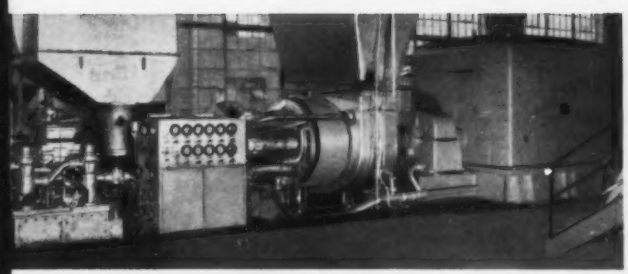
GENERAL ELECTRIC



NEW GENERAL ELECTRIC true mass flowmeter handles many different process measurements:

LIQUEFIED GASES • INDUSTRIAL LIQUIDS

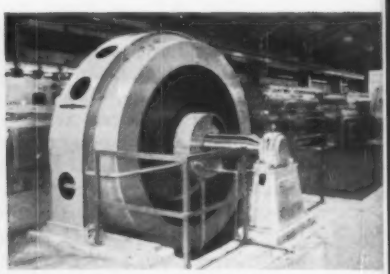
NATURAL GAS • REFINERY GAS • INDUSTRIAL GAS



INDUSTRIAL GAS TURBINES, pioneered by General Electric in 1948, are continually being improved for simultaneous double duty: reliable shaft power and economical heat for process hot air or steam.

NEW CUSTOM '8000'* a-c motors are guarded against damage from moisture and chemicals by special Polyseal* insulation systems.

*Trade-mark of General Electric Company



SYNCHRONOUS MOTORS with new and improved insulation systems operate reliably under many process conditions.

Men . . .

Damp

Shea

John M. Shea, Jr., and Ralph E. Damp have been named vice presidents, American Petrofina, Inc. They will serve as operating executives to the board of directors.

Eger V. Murphree, president of Esso Research & Engineering Co., has been elected to the board of directors of the Atomic Industrial Forum, the association of the nuclear industry. He has been a member of the General Advisory Committee of the U.S. Atomic Energy Commission since April 1957.

Ernest Artz has joined SunOlin Chemical Co. as process engineering assistant. Before joining SunOlin, Artz was superintendent of operations at the U.S. Air Force high-energy fuel plant operated by Olin Mathieson Chemical Corp. at Model City, near Niagara Falls, N.Y. He will work directly with **Richard D. Burt** who is in charge of SunOlin's current engineering planning.

Dr. Christiaan P. Van Dijk has been appointed research associate in The M. W. Kellogg Co.'s Research and Development Laboratories. Dr. Van Dijk will work in the exploratory research group at the company's laboratories at Jersey City, N. J. He was awarded his Ph.D. degree in 1946 by Delft Technical University, The Netherlands. He is also a graduate chemist of the Amsterdam Municipal University. Prior to his recent appointment, he was a member of the research staff of The Dow Chemical Co.'s laboratories, Williamsburg, Va.

Dr. Robert L. Lembke has been appointed staff physician in Continental Oil Co.'s Medical Division, with headquarters at Ponca City, Okla. He will assist **Dr. Robert R. Dugan,** assistant medical director, in administering Conoco's company-wide medical and health programs. Dr. Lembke received his bachelor's degree in 1939 from Northwestern State College, Alva, Okla. He served in the U.S. Navy during World War II and received his doctor of medicine degree in 1950 from the University of Oklahoma School of Medicine.

Wyatt L. Walker, formerly assistant superintendent of Continental Oil Co.'s Ponca City refinery in charge of catalytic and thermal cracking divisions, has been appointed assistant superintendent in charge of light oil and lubricating oil divisions. **L. S. Burke** has been promoted to assistant of catalytic and thermal cracking divisions succeeding Walker. Burke was superintendent of the refinery's Thermal Cracking Division. **Lowell H. Betow,** previously general foreman, Lubricating Oil Division, has been named superintendent of the Thermal Cracking Division, replacing Burke. All three men will continue to make their headquarters in Ponca City.

John R. Sherman has been advanced from assistant manager to manager of Warren Petroleum Corp.'s Manufacturing Division. Sherman was promoted from area manager to assistant manager two years ago. He joined Gulf Oil Corp. in 1938 and was supervisor of gas and gasoline operations in the Fort Worth office when Gulf assigned its natural gasoline plant operations to Warren in 1957, which resulted in his transfer to Tulsa as area manager and supervisor of the former Gulf plants.

Dr. Alfred E. Hirschler has been appointed research associate, and **Dr. Richard S. Stearns** has been appointed chief of the polymers, lubes and wax section, in Sun Oil Co.'s Research and Development Division. Dr. Hirschler will research special problems on an individual basis while Dr. Stearns will conduct group investigations in petroleum processes and reactions associated with polymers, lubricating oils and wax products.

Dr. Richard J. Gonzalez has been elected a member of the board of directors, Humble Oil & Refining Co. He had been coordinator of finance and economics for Humble. **Herman P. Pressler, Jr.,** now vice president and member of the board of management, Humble Division, has been named vice president and manager of public relations for Humble Oil.

James W. Bryce has joined the Whiting research laboratories, Standard Oil Company (Indiana). He will compare the economics of different processes for refining. Bryce obtained his bachelor's degree in chemical engineering at Cornell University.

William W. Bryan has been elected president of Humble Oil & Refining Co.'s Esso Standard Division. Bryan, who took office Aug. 1, is succeeding **O. V. Tracy,** who is retiring. Bryan was vice president of marketing for Carter Oil Co. before joining Humble Oil.

D. R. Johnson, Houston, has been elected vice president of Refineria Panama, S.A., which will operate a $30-million refinery now under construction in Panama. The new refinery is scheduled for completion by early 1962. Johnson will also continue as vice president and general manager of manufacturing for Conoco in Houston.

H. R. Smith has been named a vice president of Cities Service Refining Corp. He has served as general superintendent of the company since 1948. He joined Cities Service in 1923 as a refinery engineer for the Louisiana Oil Refining Co., being appointed chief engineer in 1927. He graduated from Louisiana Tech with a B.S. degree in mechanical engineering

Sherman K. Reed has been named director of research for the Chemical Division of Food Machinery and Chemical Corp. He was formerly research and development director of FMC's Chemicals and Plastics Division. He joined the firm in 1950 and has held positions with Chlor-Alkali and Niagara Chemical Divisions. He received his B.S. degree from Illinois University and his Ph.D. degree from Cornell University.

Dr. Alfred W. Wietkamp, research associate at the Whiting Laboratories, Standard Oil Company (Indiana), has been awarded the honorary degree of Doctor of Science by Midland College, Fremont, Neb. He came to Standard in 1937 after obtaining his doctorate in chemistry at the University of Nebraska.

W. S. Schellentrager, process coordinator in the Engineering Division of The Standard Oil Co. (Ohio) Manufacturing Department in Cleveland, has been temporarily assigned to Standard's Petrochemical Department to act as project manager for the Joplin, Mo., expansion of Solar Nitrogen Chemicals, Inc.

Edwin H. Young has been elected vice president of the Michigan Society of Professional Engineers. For the past two years he has served as a state director for the society. He has been on the staff in the Department of Chemical and Metallurgical Engineering at the University of Michigan for the past 13 years.

Milton Kosmin has been appointed manager of organic chemicals development for Monsanto Chemical Co.'s Research & Engineering Division, St. Louis, after serving as a senior project manager with the company's Organic Chemicals Division there.

Dr. M. J. Gattiker has been named to the board of Bataafse Internationale Petroleum Mij. He is manufacturing coordinator for the company.

WORLD RECORD IN ETHYLENE!

Stone & Webster clients produce over
2.3 billion pounds of ethylene annually
in 31 plants in 10 countries.

This world record of ethylene engineering
experience is available to you.
Call or write our nearest office.

STONE & WEBSTER ENGINEERING CORPORATION

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New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

Do you know the answer to this question?

Q. Which is taxed at a higher rate—

a fur coat? OR gasoline?

A. The tax rate on gasoline is almost 5 times as high!

Some other "gasoline tax" answers you should know!

Q. What's the average federal and state tax on ten gallons of gasoline?

A. **About <u>one dollar</u>!**

Q. How much have gasoline taxes increased in the last ten years?

A. **About <u>51%</u>! (But the price of gasoline itself has only increased 5.5%!)**

Gasoline's a buy...only the tax is high!

COMMITTEE ON PUBLIC AFFAIRS
of the American Petroleum Institute
1271 Avenue of the Americas, New York 20, New York

For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

Robert E. Roehl has rejoined Cities Service Co. after a year's leave of absence to serve as coordinator of transportation for the Oil and Gas Division of the United States Department of Interior. He will be affiliated with Cities Service International, Inc. Prior to his leave of absence in July 1959, he served as assistant to the manager of transportation and supply for Cities Service. Roehl attended the University of Kansas, the University of Southern California and Kansas State College. He joined Cities Service in 1947 as a junior engineer.

Roehl

Alexander Kidd has been elected president of Girdler Construction Corp. He was formerly vice president of Stewart-Warner Corp., Chicago, and before that was a vice president of The M. W. Kellogg Co., New York. W. R. Wood was president of Girdler Construction Corp. since its formation last October as a subsidiary of Chemical and Industrial Corp., Cincinnati, to take over the operations of Chemetron's former Girdler Construction Division.

Dr. William A. Jones, a research chemist, has been named by Texas Butadiene & Chemical Corp. to work on synthesis research at the company's Miami plant. Previously with Pan American Petroleum Corp., he joined Texas Butadiene's Manufacturing Research Department, Channelview, Texas, in March. He attended the University of Oklahoma and The University of Texas.

Lee O. Witzenburg, sales manager of the Cleveland Worm & Gear Division and Farval Division, Eaton Manufacturing Co., has been elected president of the American Society of Lubrication Engineers. Long active in the society and vice president-at-large for the past year, Witzenburg is also a member of the American Gear Manufacturers' Association and the Cleveland Engineering Society.

J. Marshall Hamill has been elected vice president of Stone & Webster Engineering Corp. Hamill is administrative assistant to the president in the Boston office. He joined Stone & Webster in 1946 and has worked on the design of chemical and petrochemical plants in Great Britain and various parts of the U.S. He is a native of Tulsa, Okla., and served in the U.S. Navy during World War II.

Robert H. Scholl has been appointed director of public relations, Standard Oil Co. (New Jersey). He is executive vice president of Esso Standard Division, Humble Oil & Refining Co.

Edward N. Leibacher, a veteran of 44 years in the oil industry with service in technical and managerial posts in the United States, Europe and Asia, has retired as a vice president and director of Standard-Vacuum Oil Co. Leibacher's petroleum career started at Esso Standard's Bayway refinery in Linden, N.J., after graduation from Pennsylvania State University with an engineering degree in 1916. He went to Sumatra in 1928 to supervise construction work at the Sungei Gerong refinery near Palembang. Upon the formation of Standard-Vacuum as an integrated company in 1933, he joined the new organization's headquarters staff in New York City. He again was assigned to Sumatra in 1937, this time as assistant general manager of Stanvac's producing and refining affiliate there. In 1947 he was named coordinator of Indonesian affairs for Stanvac, New York, the position he held when elected a director on June 12, 1951. He has been a vice president since May 1955.

Warren C. Johnson has been named president of Lomita Gasoline Co. **M. S. Hubbell** has been appointed manager of the company. Lomita, which operates two natural gasoline plants in the Long Beach, Calif., area, is a subsidiary of Standard Oil Co. (California).

— Deaths —

James A. Ahearn, executive vice president and director of Sinclair Refining Co., died July 12. He was 58. He was vice president and director of transportation, supply and distribution for Sinclair Refining.

David T. Shaw, former manager of The Atlantic Refining Co.'s Philadelphia refinery, died July 1 in Philadelphia. Shaw, 66, joined Atlantic in 1929 as a senior engineer in the firm's Research and Development Department.

Frank V. Long, Sr., 60, president of The Vapor Recovery Systems Co., Compton, Calif., died June 27. Long had been suffering from a heart ailment for the past three years.

Now turn to Page 220 and read "Suppliers Notes" to keep informed about those who supply and service the industry.

Facts-of-Life for successful engineers must include attitude, self-appraisal, vision, understanding, respect, relaxation and "happiness"

Achieving "success" and/or "happiness" in your professional and personal future won't just "happen," regardless of how diligently you apply yourself to your daily tasks, unless your efforts are coordinated along specific paths of endeavor. Your life as an engineer must be counterbalanced by your life as an individual — because "engineers ARE human," despite comment to the contrary.

The engineer reacts to the same human stimuli and motivations as the man in the accounting division, the sales department, the repair and maintenance crew, the general office force, or in the management division. All are motivated to varying extents by the same drives for recognition, self-respect, material progress, functional importance, personal pleasure, financial stability — and "security," however, the latter is translated.

The fact of the matter is no longer "theoretical," it is accepted, proven, practical "common-sense": to accomplish either or both of these achievements, your pursuit of "happiness" and/or "success" must have (a) ambition, (b) definition, (c) purpose, (d) direction. It is a life-long pursuit, subject to many detours and changes. In the pursuit itself, however, will be found much of its own reward.

One of our basic problems seems to stem from our relationships with *others* — our reactions to the drives of other people and their reactions to ours, because, like it or not, we *are* affected by other people, and they are affected by us.

Professionally, we are affected by our superiors, associates and subordinates — both technical and non-technical. Personally, we are affected by our family, our relatives and our friends — on and off the job. Our object then, is to ascribe to both our professional and personal life those qualities and human attributes which bring professional success and personal happiness. *We must develop a formula for living.*

This limited space, of course, does not permit a full look at this most complex of subjects, but a more complete treatment of human relations in engineering is found in a booklet entitled "Success and/or Happiness — in Engineering," available free upon request. Write for your copy to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and remember, *our* success and happiness stems partially from the heat exchangers in *your* future.

For more data on advertised products, use Readers' Service Cards, last page.

SARCO

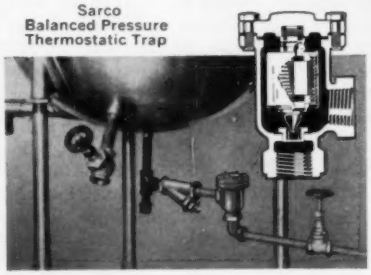
NOW...MATCH STEAM TRAPS

THERE'S no such thing as an all-purpose steam trap. That's why it pays to know what each trap has to offer. Here are five examples that demonstrate how you can match the correct steam trap type to the exact requirements of *each* application.

EXAMPLE 1: Outside Tracer Lines: A tough set of requirements

One of the most demanding sets of requirements a steam trap has to face is found in *outside steam tracing*. The trap must not only rid tracer lines of condensate and air immediately they're formed, but it must do so under exacting conditions. Pressures on each trap may vary widely. Installations may be remote and inaccessible to service. Water hammer may be a constant threat; freezing may be a hazard. Only the unique Thermo-Dynamic trap takes all these demands in stride. The Sarco TD-50 operates perfectly *without adjustment* through its full pressure range of 10-600 psi. It's virtually immune to water hammer and won't freeze when installed with a free discharge. Maintenance is, therefore, negligible. Compact, requiring no external support, the TD-50 is just about the easiest trap in the world to install. Once it's installed, you can forget it. You can count on an extremely long, trouble-free service life with minimum maintenance attention.

More closely than any other model, the TD-50 approximates an all-purpose trap. However, special application requirements might dictate the use of another type of Sarco trap. Sarco engineers stand ready to help you solve any trapping problems.



EXAMPLE 2: For steam jacketed process kettles: a trap that operates immediately on start-up and self adjusts to both low and high pressures

When a large steam-jacketed process kettle starts up, the condensate load is high, and all air in the jacket must be released quickly. At this stage, however, the jacket pressure is low; yet it builds up rapidly as the process continues. Because a SARCO No. 9 Balanced Pressure Thermostatic Trap is wide open on start-up, it releases initial air and condensate without the need for a bypass. And because it is self-adjusting, it works just as efficiently during the first processing stage when the jacket pressure is high. There are no seats to change for various working pressures. You can see why it is the obvious choice for steam jacketed process kettles.

EXAMPLE 3: How to prevent water-logging in unit heaters and blast coils

All unit heaters and blast coils have a relatively small internal volume in comparison with their steam condensing capacity. Even slight water-logging can reduce heat output seri-

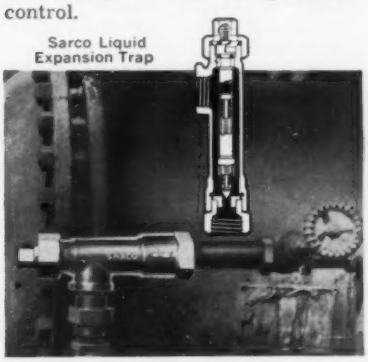
Impartial advice on trapping because
ONLY SARCO MAKES ALL 5 STEAM TRAP TYPES

TOPICS

TO YOUR TRAPPING NEEDS

ously. Pressures may vary widely under automatic temperature control and so may the load because of variable demand. A trap to handle this application must adjust itself instantly to pressure and load charges. The most precise answer to this problem is the SARCO Float and Thermostatic Trap—and here's why: it releases air on start-up and during running, and, because it discharges condensate continuously, it does not set up in the system violent pressure changes that would upset close control.

Sarco Liquid Expansion Trap



EXAMPLE 4: How to release low temperature condensate

When condensate cannot be returned to the boiler feed tank either because of distance or because it may be contaminated, it's economical to utilize some of the sensible heat as well as the latent heat of the steam.

For this purpose a trap must be capable of releasing condensate to temperatures as low as 100° F.

The sound trap selection here is the SARCO No. 871 Liquid Expansion Trap because it can be set to release condensate at temperatures down to 100° F. regardless of supply pressure. This performance assures maximum steam economy. The Sarco No. 871 handles the starting load easily because of its wide open valve, which throttles the flow as the condensate temperature rises. Furthermore waterhammer cannot reach the operating element. No other type is as nearly perfect for this specific problem.

Sarco Bucket Trap

EXAMPLE 5: Economic handling of Water Hammer and Corrosive Conditions

In applications in which water hammer or corrosive conditions are encountered but in which low pressures or extremely high back pressures preclude the use of the Thermo-Dynamic trap, the Sarco Inverted Bucket Trap is recommended. While the Sarco I. B. is not exactly a fuel miser, its relatively rugged construction will withstand considerable water hammer; and, when it is fitted with stainless steel internal parts, it offers excellent resistance to corrosion.

* * *

CONCLUSION: The right application is the economical installation

When you choose steam traps that serve their purpose without frequent adjustment, and without maintenance or replacement problems, you save on down-time, man-hours, spare parts, and production slowdowns.

You can get the money-saving solution to every trap selection problem by consulting Sarco. You get impartial solutions, because only Sarco makes all 5 types of steam traps: Thermo-Dynamic*, Thermostatic, Float Thermostatic, Liquid Expansion, and Bucket.

You also get the benefit of Sarco's 50 years of specialized experience in the manufacture and application of temperature regulators, industrial air vents, pipeline strainers, dial and industrial thermometers, heating and cooling controls, heat exchangers, heating control systems and heating specialties.

For literature or impartial help in solving your steam trapping or control problems, contact your local Sarco Sales Representative, or write direct to Sarco. 1440

*U.S. Pat. No. 2,817,353. T.M. Reg. U.S. Pat. Off.

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers Notes...

Van Iderstine

Yetka

THE PERMUTIT CO. has formed two new divisions—a Chemical Division and an Industrial Division. **Robert Van Iderstine,** assistant general manager of Permutit, will become general manager of the Chemical Division. The Industrial Division will be headed by **Julius Yetka,** former Permutit controller. The Chemical Division will operate as the Ionac Chemical Corp. and the Industrial Divison will continue to do business as the Permutit Co. The new divisions will be under the supervision of **George N. Proctor,** Pfaudler Permutit vice president and general manager of The Permutit Co.

MAGNAFLUX CORP. has appointed **Kermit A. Skeie** head of commercial inspection, **Denis P. Walsh,** manager of distributor and representative sales; and **Robert G. Strother,** in charge of field engineering. Skeie, a graduate of St. Olaf College, was Western Region manager. Walsh, who was Midwest Region manager, studied at Wayne University, Detroit, and the University of Michigan. Strother has been Eastern Region manager for Magnaflux for the past five years. He studied mechanical engineering and metallurgy at the University of California.

W. A. STOELTZING, INC., Pittsburgh manufacturer's representative, has announced that **G. R. (Dick) Winder** is now associated with them. Winder was formerly vice president and general sales manager of Chiksan Co., division of F. M. C., Brea, Calif., and vice president of marketing, OIC Valves, Wadsworth, Ohio. Winder will also be associated with Forbes-Western, Inc., which represents other manufacturers.

MICRO-PATH INC., a wholly-owned subsidiary of United Industrial Corp., has formed an Instruments Division with the acquisition of manufacturing, sales and distribution rights to all electronic and chemical devices produced by Robert R. Austin Laboratories, San Gabriel, Calif. The company intends to further expand its Instruments Division operations into the fields of industrial instrumentation, and instruments for the petroleum-petrochemical industries.

BAIRD-ATOMIC, INC., AND HILGER & WATTS, INC., Chicago, have entered into a U. S. sales and service agreement with Hilger & Watts Ltd., London, manufacturer of scientific and engineering instrumentation. Under the arrangement Baird-Atomic will sell, install and service Hilger & Watts units which complement its own line.

JEFFERSON CHEMICAL CO., INC., has elected **John D. McPherson** president and director. McPherson joined Jefferson in 1955 as vice president of operations. He is a graduate of Auburn University where he received his B.S. degree in chemistry. He was manager, Manufacturers' Chemicals Department, American Cyanamid Co. before coming to Jefferson Chemical.

NORTON CO. has appointed **J. Robert Lowry** and **Robert D. Stubblebine** to its grinding wheel field sales force. Lowry, a native of Pittsburgh, is a graduate of the University of Pittsburgh. Stubblebine, of Worcester, is a Cornell University graduate. Both men joined the company as sales trainees last year.

ELKHART BRASS MANUFACTURING CO. has appointed **Joe L. Risinger** technical director. Risinger retired as head of safety and fire protection for Socony Mobil Oil Co., domestic and foreign, June 1956. Since that time he has been advisor to the Iranian Oil Refining Co., Ltd., Abadan, Iran, special fire and safety consultant for Safety First Products Corp., and industrial consultant. In addition to his affiliation with Elkhart, Risinger will continue as a consultant with Safety First as oil, gas and petrochemical representative. Risinger is the author of articles on safety and fire protection published in PETROLEUM REFINER in 1957.

Risinger

FOOTE MINERAL CO. has named **William A. C. Eldon** operations manager of the New Hampshire plant. Eldon has been with Foote Mineral since 1950 and has served at the company's Exton, Pa., and Kings Mountain, N. C., plants in an engineering capacity.

GRAYBAR ELECTRIC CO., INC., has appointed **F. B. Murray** manager at San Antonio, Texas, replacing **R. N. Ness,** who will assume special duties in Dallas. Murray joined Graybar as a salesman at Ft. Worth in 1949.

Fulton

Danielsen

BAILEY METER CO. has appointed **H. R. Fulton** and **A. L. Danielsen** regional sales managers. Fulton will be in charge of region 1 in Pittsburgh, and Danielsen will head the region 4 sales office in Denver. Fulton joined Bailey Meter in 1924. He graduated from Penn State University, where he received his B.S. degree in mechanical engineering. Danielsen came to the company in 1940 after graduating from the University of Illinois.

FIREBOARD PAPER PRODUCTS CORP. has appointed **Leonard A. Carey** merchandising manager for distributor and nonfood consumer packaging. Carey has been connected with packaging sales, sales management and sales administration for Northern Packaging Division.

THE TIMKEN ROLLER BEARING CO.'S Engineering Division has named **H. J. Urbach** director of engineering, and **Ralph McKelvey** assistant director of engineering. Urbach was formerly company executive engineer and McKelvey was assistant chief engineer of the Physical Laboratories.

OIL WELL SUPPLY DIVISION of U. S. Steel Corp has appointed **Lail Hamilton Shaw, Jr.,** assistant district engineer, New Orleans. Shaw joined the company in 1957 as a junior engineer. He graduated from The University of Texas in 1957.

PARKER SEAL CO. has appointed **Donald L. Wilson** representative for Parker Seal products in the Western Ohio and Eastern Pennsylvania area. Wilson, who attended Akron University, was formerly with Dayton Rubber Co., Dayton, Ohio.

CATALYSTS AND CHEMICALS, INC., has named **E. O. Northcutt, Jr.,** technical service engineer. Northcutt received his B.S. degree in 1951 from Vanderbilt University. He served in the Korean War as an officer in the U. S. Marine Corps. The past six years he has been associated with plant engineering and technical service as a process engineer.

REXALL DRUG AND CHEMICAL CO. has named **Arthur B. Wintringham** administrative director of the Chemical Divi-

"Bimetal Freeze-up" Can Be More Serious Than Dial Fogging Problem

The first sign of moisture in a dial thermometer usually shows up as condensation inside the dial glass. You are probably familiar with this dial fogging problem which causes difficult reading and the eventual corrosion of the bimetallic element. You may not, however, be familiar with another and actually more serious moisture problem —bimetal "freeze-up."

Both dial fogging and bimetal freeze-up are permanently prevented by RMC's dry air hermetic sealing process.

If moisture is sealed in, or enters a thermometer dial it will find its way to the bimetal element. Then at extreme low temperatures this moisture freezes on the element and bearing surfaces, and the bimetal element will not function should the temperature go lower. Therefore, the operator of the equipment would never know that the temperature had gone below the last indication when the element became frozen.

Here's what makes such a condition hard to spot. The thermometer would operate properly again after a temperature rise of perhaps 20°, and would continue accurate indication even though the fluid dropped again to an even lower temperature than before. However, after it remained at the new low for a few hours, it would again freeze up. Then, as before, any further drop in temperature would not be indicated.

Only a dry-air hermetic seal, as used by RMC, can prevent both dial fogging and bimetal freeze-up. RMC even goes a step further by providing for recalibration at any time without breaking the air-tight seal. An external dial reset screw—exclusive with RMC—permits recalibration without opening the instrument in any way.

New RMC 3-inch Straight Form Thermometer

RMC's 3-inch Straight Form Thermometer (Model #1740) has full view dial, parallel to stem. Stem can be located at any specified position around entire circumference of head. Has patented RMC *external recalibration device* and *silicone dampening*. Hermetically sealed.

ROCHESTER MANUFACTURING CO.
38 Rockwood St., Rochester 10, N.Y.

These RMC thermometers have just been submerged in water for the first of a severe series of tests to make sure of perfect hermetic sealing.

Moisture will never bother your RMC dial thermometer

The RMC hermetic sealing process makes absolutely certain that humid air will not be sealed in the instrument and locks all moisture out permanently. Each thermometer then goes through a series of severe tests. Only those with perfect sealing are accepted for delivery. When you order from RMC you get the *only* industrial thermometer that can *never* be affected by internal dial fogging or bimetal freeze-up.

RMC

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

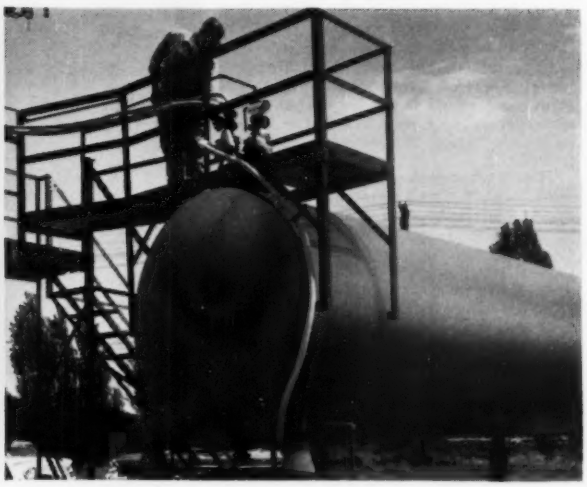
LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

For more data on advertised products, use Readers' Service Cards, last page.

FLUIDICS* AT WORK

Storing a sticky fluid? . . . an ultra-pure one?



. . . a harsh corrosive?

Glasteel thrives on solving problems like these

"Problem Storage" is a primary area for the Glasteel storage tank.

If your product is sticky, Glasteel helps you overcome the cleaning problem. Because it's glass inside (steel outside), your Glasteel tank meets the product with a smooth, glossy surface unmatched by even the most highly finished metal or plastic. Your product has little chance to adhere or build up residue in a Glasteel tank.

If it is sensitively pure, your product will pick up no impurities from a Glasteel tank. Glass is inert. Never puts itself into the product. It protects the purity, flavor and aroma of whatever you store in it. That's why it should be no surprise to learn that Glasteel storage is a standard practice in the pharmaceutical industry.

If it's a corrosive, you can store your product safely in Glasteel. Glasteel is completely resistant to all acids (except hydrofluoric) and to alkalies at ambient temperatures.

Save two ways. The profit return with Glasteel storage tanks is reflected in two ways:

#1. In tanks of 10,000 gallons and more, Glasteel is actually lower in price than stainless steel. In the 30,000 gallon range they cost half as much. These savings are immediate.

#2. In tanks of *any* size you save money when storing corrosives, because Glasteel tanks last 20 years and more, require little maintenance.

More information. Our Bulletin 975 spells out the economic facts and specifications for Glasteel storage. We'd be happy to send you a copy, or to answer specific questions. Write to the address shown on the facing page.

For more data on advertised products, use Readers' Service Cards, last page.

What's new in reactors?

The silhouette of this reactor is different from our earlier "R" series. So is the exterior color—a light blue. In fact from top to bottom this Pfaudler® "RA" Series Reactor is new.

Two new drives. Select the TW for power requirements up to 15 H.P., or the BH if your needs take you up to 60 H.P. and higher. Both are compact, easily installed and maintained. Both are very quiet, too, a much-appreciated difference when a full line is in operation.

Mirror-image top head. The symmetrical pattern formed by an equal number of nozzles on each half of the top head means you need only a minimum of headroom and pipe to hook up an "RA" reactor. You can also feed two side-by-side reactors from a single tee.

Offset drain. You get fast drainage because the outlet is offset and in the direct sweep path of the agitator. The outlet is in line with the top-head manhole for convenient inspection.

Corrosion resistance. Inside there's Glasteel 59 for resistance to all acids (except HF) to 350° F., and even 450° F., depending on concentration. Mild alkalies at moderate temperatures are also permissible. Thermal shock resistance is 30% greater than in the "R" Series. Abrasion resistance has been increased by 20%.

And the smooth surface that resists build-up gives you high heat transfer, increased product yield, fewer shutdowns for cleaning.

Stock delivery. Two weeks from receipt of your order you can have delivery on 500, 750, 1000 and 2000 gallon vessels. We need a little more time for other standard sizes through 4000 gallons.

New Bulletin 988 puts all the details at your finger tips. Write for it.

How to match the material to the application

This solvent recovery condenser has 733 square feet of heat transfer surface. It took 140 one-inch-diameter Monel tubes, 20 feet long, to provide this. The shell and expansion diaphragms are also made of Monel. Bonnets are carbon steel. This unit will be used at 75 psi, at 400° F. For a more corrosive service, a duplicate design is being made of Carpenter—20 Cb.

All of which leads us to the point that you get the right materials that best suit your application when you come to Pfaudler.

We are in the unique position of offering a complete choice—in solid or lined construction. We can pick from (in *combination* where needed) Glasteel, Monel, Hastelloy, nickel, aluminum, stainless, Inconel, tantalum, titanium, zirconium, etc.

Outline your problem and you will receive a prompt, thorough recommendation.

Put F-C Glasteel Pipe† to work with just four easy steps

Here's a corrosion-resistant, high-integrity, lined pipe that you can install in four easy steps.

First take a section of Pfaudler F-C Glasteel Pipe (the F-C means "field cut") and cut to the length you want on a standard, dry abrasive cutoff wheel.

Next, thread—just as you see in the picture.

Third step: Fire-polish using a small, portable furnace. (You can get one from Pfaudler at a modest cost that you will *recover* through the savings from a few installations.)

Then, thread on flange and belt sand to assure that gasket seat is flat and the flange connection seal-tight.

Details: This pipe is ⅛ inch glass inside, steel outside. It resists most acids to 350° F. and handles alkalies at moderate temperatures. It's pressure rated at 150 psi and you can currently get fast delivery on 1½, 2, and 3-inch diameters in lengths through 10 feet. Ask for Bulletin 989.

Address all inquiries to our Pfaudler Division, Dept PR-80, Rochester 3, N. Y.

FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in Germany, Great Britain, Canada, Mexico, and Japan, as well as the United States.

†Patent applied for

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

Suppliers . . .

sion. Wintringham, formerly with Ethyl Corp., Baton Rouge, La., is a chemical engineering graduate of Rensselaer Polytechnic Institute.

AMERICAN METER CO. has appointed **Ronald M. Roberts** sales representative for the Atlanta Sales District. Roberts was division measurement engineer for Houston-Texas Gas and Oil Corp., St. Petersburg, Fla., before joining American Meter. He has completed the company's six month gas measurement school at their Erie, Pa., plant.

CONTROL DATA CORP. has appointed **Dr. Tai Nien Feng** associate director of research. Dr. Feng will serve as a staff consultant to Cedar Engineering Division. Dr. Feng was consulting engineer for John Oster Manufacturing Co.'s Avionics Division before joining Control Data.

CHICAGO BRIDGE & IRON CO. has purchased the field automatic overlay welding operations of The Portland Co. Major personnel of the Portland Overlay Welding Group also joined C B & I as part of the transaction. They are **Zane S. Blanchard,** division manager, **Charles E. Jackson,** chief engineer; and **David J. Kingsbury,** sales manager.

DELTA TANK MANUFACTURING CO., INC., has appointed **Dick L. Herrick** sales representative, Lafayette, La., oilfield equipment office. Herrick has been in sales and service of oilfield equipment the past two years. He graduated from Tulsa University in 1957.

WESTON INSTRUMENT DIVISION has named **Harold L. Russell** sales manager in charge of process instrument sales. Russell transfers to Weston from the Fischer and Porter Co., Hatboro, Pa. He is a 1949 graduate of the University of Pennsylvania in electrical engineering.

EXNER-DODGE, INC., has appointed **Dean D. Collins** district sales representative, Shreveport. Collins will cover territory including Northern Louisiana, Mississippi, Arkansas and East Texas. He has been in the oil and gas industry 28 years. He was previously district manager for Rockwell Manufacturing Co. Collins majored in petroleum engineering while at Oklahoma University, Oklahoma State University and Tulsa University.

Collins

RUSSELL REINFORCED PLASTICS CORP. has named **Dr. Mandell S. Ziegler** director of research and development. Dr. Ziegler has been with E. I. duPont deNemours & Co., research and sales divisions, Polychemicals Department.

NATIONAL CAN CORP. has appointed **Law G. Weiner** supervisor of customer service in the firm's Central Division Research Department. Weiner started in the can industry as a chemist.

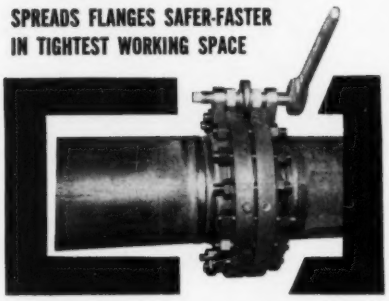
PENNSALT CHEMICALS CORP. has appointed **Albert Rozensky** technical service engineer in the Corrosion Engineering Products Department. Rozensky was a senior chemist for Thompson & Co., Oakmont, Pa., for three years. He holds a B.S. degree from the University of Pittsburgh.

SOUTHWESTERN ELECTRONICS CO., a division of Dresser Industries, Inc., has named **Hugh A. Young** Western engineering consultant. Young is a graduate electrical engineer from the University of California.

BECKMAN INSTRUMENTS, INC., has appointed **Dr. Lorand von Kurtos** general manager of the Munich, Germany, branch. Dr. von Kurtos formerly was associated with Leybold High Vacuum, Cologne.

"SAFETY BOY"

SPREADS FLANGES SAFER-FASTER IN TIGHTEST WORKING SPACE



- Eliminates plant safety hazards and costly down time.
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- Lightweight / Priced right

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LOW COST, HIGH CAPACITY, LOW H.E.T.P.
MINIMUM PRESSURE DROP, PROVEN COMMERCIALLY

306 Installations to date—19mm. to 67.75 in. dia.

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REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
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DU PONT *Petroleum Chemicals* NEWS

Number 103 in a series of bulletins for the Petroleum Industry

AUGUST 1960

Du Pont reports on the progress of linear programming

HERBERT O. BAILEY and JACK S. BELLAH, refinery technologists, discuss the programming of a customer's refinery operation.

The purpose of the Du Pont linear programming service is to help refiners look at *both* the forest and the trees – to analyze the economic effect of every processing and blending phase, and from this analysis obtain an over-all view of the economy of a particular refinery's operation.

In one instance, linear programming showed how a company was losing over $1 per barrel by diverting one component to a less profitable alternate use.

In another case, a company learned that it was buying a component at a price considerably above its actual value to them.

Du Pont has now expanded the scope and capabilities of its linear programming service. The past and the future of this service are explored in the statements on this page by Jack S. Bellah and Herbert O. Bailey, Du Pont refinery technologists.

Linear programming up to now by Jack S. Bellah

"In the past two years the many customers who have utilized our linear programming service have found it to be a useful adjunct to their over-all refinery operations and planning.

"On occasion, the analyses they received opened the door for changes which could effect appreciable economies. In other instances, results have verified that the *modus operandi* of the refiner was already at the optimum.

"Du Pont instituted this service with two purposes in mind:

"First, as a study of a customer's actual operations – to develop the over-all economic picture of his gasoline blending operations, putting all factors into their proper economic perspective when maximizing profit. From this, much information can be readily developed on the effect of varying elements of the system.

"Second, where the customer is interested in linear programming as a permanent tool in his own economic studies, a trial run by Du Pont can give him experience on which to base his own choice of programming system. In some cases, Du Pont has helped to train those persons who will make the actual studies, and has continued to suggest ways in which the studies can be broadened into more comprehensive and useful management tools."

The future for linear programming

by Herbert O. Bailey

"We expect to expand the Du Pont linear programming service by introducing more customers to it and by exchanging ideas, concepts and methods with those who have already started using it.

"One new approach is our use of the IBM 704 computer. The larger memory capacity of this machine helps us assist our customers in studying larger and more complex problems, including: maximizing the profit on numerous grades of gasoline; interseasonal storage of gasoline and heating oil components; complete refinery simulation from crude to finished products.

"On the 704 we can, within reasonable limits, incorporate in a single problem the combination of variables that determines:

a) Selection of crude slates.

b) Determination of reforming severity level and tetraethyl lead concentration for minimum cost research and motor octane numbers.

c) Choice of catalytic cracking plant feed stocks.

d) Disposition of butanes among motor gasoline, alkylation or polymerization plant feed stock.

e) Component and finished product production within process capacity limitations, and with all finished products meeting specifications.

f) Size of profitable marketing areas."

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

ATTENTION MARKETERS:

New survey probing motorist buying habits soon to be released

Now in the final stages of compilation is the 1960 Du Pont survey, "Profile of the Motorist". This is the fourth in a series that constitutes the largest such study ever undertaken in the petroleum industry.

Coast-to-coast interviews (4,500) are shedding new light on old questions, such as: gasoline brand preference, loyalty to service stations, the effect of price wars on buying habits, regular-vs-premium grades, and non-petroleum purchases at service stations.

Other areas of particular interest include: the growing use of non-oil company credit cards, vacation use of automobiles, the effect of trading stamps and activities that compete with driving (such as home swimming pools, daytime television).

This study is another example of the marketing services available to Du Pont customers. Results will be available this fall.

Du Pont study shows fewer gasolines cause carburetor icing

Results are now available to marketers and refiners from the *Winter, 1960,* Du Pont Survey of Carburetor Icing.

30 regular grade gasolines, 30 premiums, and 4 super premiums were investigated. Samples were obtained from service stations in various marketing areas, with particular emphasis on regions where carburetor icing has been most prevalent.

Contrasted with results of the 1959 survey, it appears that there was a general decrease in the tendency of motor gasolines to cause carburetor icing:

47% of *regular* gasolines were satisfactory, compared with 35% in 1959.

63% of all *premium* gasolines were satisfactory, compared with 55% in 1959.

Full information on this study – including the comparison with last year – is available from your Petroleum Chemicals Division representative.

Western Regional Manager

E. HEARN SIMPSON, who recently assumed the duties of Western regional manager for Du Pont's Petroleum Chemicals Division, brings more than twenty-four years of petroleum experience to his new position. He succeeds the late Robert F. Harwick.

Mr. Simpson started with Du Pont in 1930 in the sales department of the "Fabrikoid" Division, Newburgh, N. Y., and two years later became a sales correspondent in the Alcohol Division of the Organic Chemicals Department in Wilmington, Del. In 1934 he became a salesman in the same division, where he was concerned with the sale of gasoline antioxidants, oil colors, and alcohol in the Middle West.

From 1943 until 1946 Mr. Simpson was a supply officer in the U. S. Navy. He returned to Du Pont in 1946 as sales manager of the alcohol and camphor section, Petroleum Chemicals Division, and a year later was named assistant sales manager of petroleum additives. In 1950 he was appointed manager in charge of industrial sales for the Petroleum Chemicals Division and the following year was named acting manager of the Eastern Region with headquarters in New York City. In 1952, Mr. Simpson returned to Wilmington as manager of sales of the Petroleum Chemicals Division, a post which has now been discontinued.

A native of Washington, D. C., Mr. Simpson attended public schools in Delaware, Oklahoma, and Colorado, and joined Du Pont following graduation from the University of Denver with a bachelor of science degree in 1930. He is a member of the American Petroleum Institute.

New Du Pont yellow dye is 20% stronger, more soluble

Now you can add yellow color to gasoline and other petroleum products more readily with Du Pont's new Oil Yellow NB. This new dye is 15% to 20% stronger than its predecessor, Oil Yellow N.

Use less dye. With Oil Yellow NB you use less dye to get the same results obtained up till now with Oil Yellow N.

Improved solubility. Another advantage of Oil Yellow NB is its greater solubility in petroleum products. Its approximate solubility, ascertained from test samples, is 4000 mg/100 ml in a test gasoline, compared to approximately 2000 mg/100 ml for Oil Yellow N.

Now available. Deliveries of Oil Yellow NB are now being made from our plant at Carneys Point, N. J., and from warehouses across the United States. The dye is shipped in standard 100-lb.-net packages.

With Oil Yellow NB you can add the advantage of *faster dyeing* to that of *lower dye requirements.* For additional information and samples, contact your Du Pont representative.

SALES OFFICES

Chicago 3—8 So. Michigan Ave. . . . RAndolph 6-8630
Cleveland 15—101 Prospect Ave. . . . . MAin 1-3422
Houston 2—705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. . . MAdison 4-1354
New York 20—45 Rockefeller Plaza . . . . . COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza . LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-1934
Seattle 3—4003 Aurora Ave. . . . . MElrose 2-6977
Tulsa 1—1811 So. Baltimore Ave. . . . . LUther 5-5578
In Canada—Du Pont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12,** Ontario . . . . . HUdson 1-6461
OTHER COUNTRIES: Petroleum Chemicals Division, Export Sales, Wilmington 98, Delaware . . . . . PRospect 4-2962

DU PONT
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Better Things for Better Living
. . . through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-15405

Printed in U.S.A.

Suppliers . . .

CRAWFORD & RUSSELL, INC., has opened a sales-service office in Cleveland. **Theodore W. Dwight, Jr.,** has been named manager of central sales. A chemical engineering graduate of Yale University, Dwight, worked in production engineering for General Electric Co. before coming to Crawford & Russell. He also was with The Dow Chemical Co. as a process and project engineer.

Dwight

PANELLIT SERVICE CORP., Skokie, Ill., subsidiary of Information Systems, Inc., has appointed **Archer Wombacher** national sales manager. Wombacher comes to PSC from Genesys Corp., the Computer Products Division of Information Systems, Inc. He is a graduate of the University of California.

CALUMET & HECLA, INC.'S, Wolverine Tube Division has named **Robert L. Chiddister** sales representative in the Chicago metropolitan area. For the past 10 years, he was territorial supervisor of sales with NIBCO, manufacturer of copper fittings and valves.

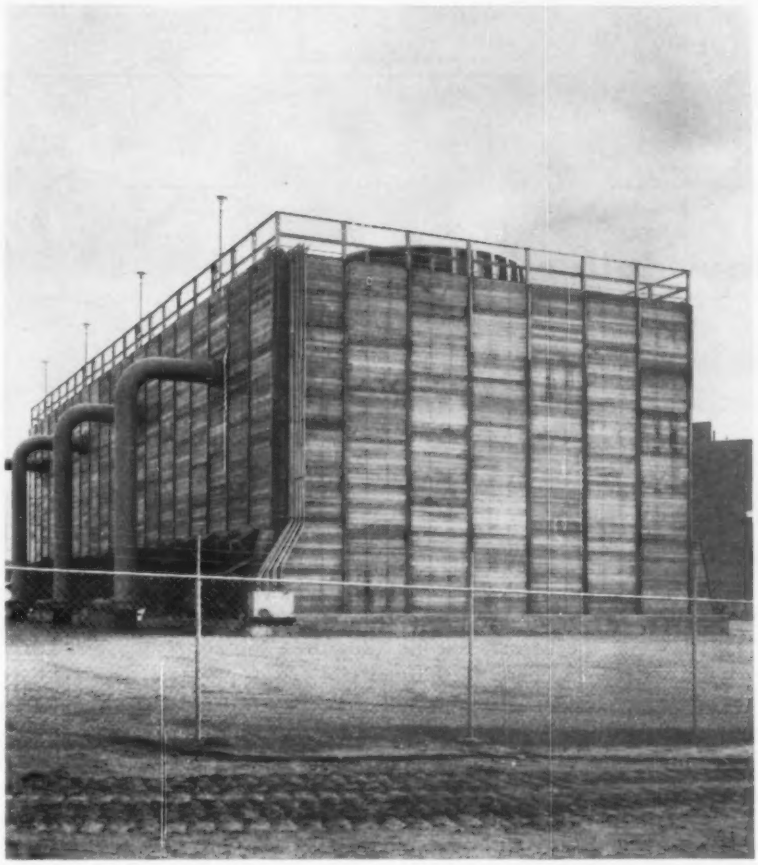
HAGEN CHEMICALS & CONTROLS, INC., has named **James H. Holben** assistant director of Bradford Laboratories. Holben had been manager of Bradford's service laboratory, Evansville, Ind., before his appointment. He joined Bradford Laboratories in 1949 as a field service engineer. He graduated from Grove City College, Pa. He will be in charge of all oilfield water service.

Holben

PITTSBURGH-DES MOINES STEEL CO. has elected **R. Y. Kopf** and **R. E. Kramer** to its 10-man board of directors. Both men have been with PDM as vice presidents since the merger with Hammond Iron Works in December 1959.

F. J. STOKES CORP. has appointed The Hainge Co., Inc., manufacturer's representative in the Southwest. The firm, headed by **Robert F. Hainge,** specializes in the sale of capital equipment to the metalworking, plastics and chemical process industries.

CORROSION COSTS CAN BE LOWERED



No matter how you figure it—in terms of replacement costs, treatment costs or higher production—Hagan can save you money by keeping cooling and service water systems at top efficiency. Complete treatment recommendations, based on experience with water problems in every kind of industry, are backed up by continuing service after treatment is started. Hagan's methods have achieved these results:

LOWER CHEMICAL COSTS: In most systems, treatment is more effective. This means that smaller amounts of chemicals can be used.

LOWER WATER COSTS: With more effective treatment, it is frequently possible to maintain higher solid concentrations in cooling water. This means less makeup water, and consequent savings in overall water costs.

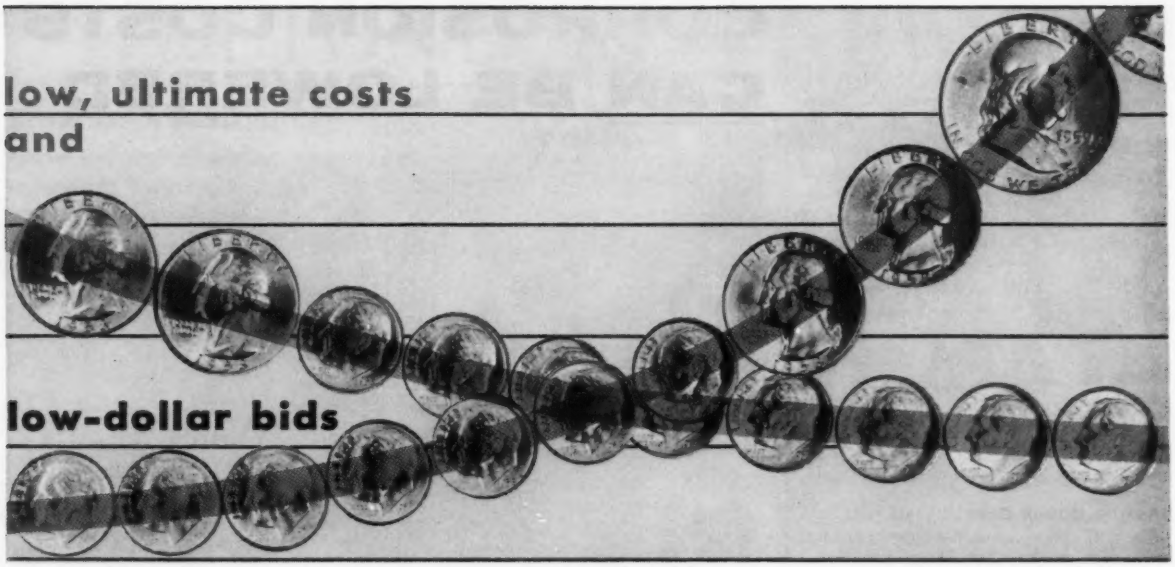
BETTER RESULTS: In many plants, Hagan methods have reduced corrosion rates to 1 mil per year or less. At the same time, troublesome deposits were eliminated, increasing equipment efficiency, and overall chemical costs were lowered.

A letter or phone call will put Hagan Engineers to work on your particular water problem.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO., HALL LABORATORIES, BRUNER CORP

For more data on advertised products, use Readers' Service Cards, last page.



are not the same

The historic struggle between long-range economy and "low-dollar" first-cost is brought into extremely sharp focus in the competitive bidding for heat transfer equipment sales in the process industry . . . especially where *continuous flow* processes are involved.

Recognition of *all* factors contributing to the economy of such continuous, uninterrupted operations has become the cornerstone of Western's appraisals and solutions. It is further reflected throughout the design, mechanical, thermal and rating phases of the engineering of each Western Heat Exchanger.

Western engineers understand this "fact of life": we must, to the best of our ability, anticipate the *continuing expense* of operation and maintenance of heat exchangers, so that such ultimate costs are kept at a minimum, and our exchangers *operate at a profit* for our customer. Otherwise, it is false economy indeed, regardless of the "initial cost."

Western Heat Exchangers are quoted for *long-range economy,* not short-sighted "low-dollars" . . . and a visit with a Western engineer will show you how and why.

WESTERN'S STAKE IN YOUR FUTURE

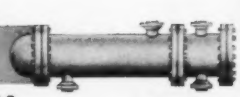
In today's "business arena" it is increasingly important for process engineers to take the *full* look at *true economy* in the production of chemical and petro-chemical products. Pointing to the need for such understanding is the next of Western's "professional-advancement" messages, shown at right, currently seen in leading petroleum and chemical trade journals . . . and available in more complete detail in pamphlet form, upon your request.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

serving the growth of the process industry

WESTERN

HEAT EXCHANGERS



WESTERN SUPPLY COMPANY

P.O. Box 1888 – Tulsa, Oklahoma

"LOW FIRST-COST vs. LOW ULTIMATE COST" controversy demands understanding of economics involved

When is a "low bid" really low? This perplexing question consistently faces the engineer charged with the responsibility of ordering capital process equipment with a wary eye towards the profitability of such equipment in his company's long-range economy, yet, beset with the necessity for tightly-budgeted current operations.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Florence

Safreed

THE CLEVELAND CRANE & ENGINEERING CO. has elected **Herbert T. Florence** president and general manager. **Charles F. Safreed** has been named chairman of the board. Florence started with Cleveland Crane & Engineering 37 years ago as an apprentice. Safreed is one of the founders of the McNeil Lincoln Engineering Co. Florence succeeds Safreed as president.

CONTINENTAL-EMSCO CO. has promoted **Godfrey Cajthaml** district manager, C-E's Calgary, Alta., district. **Reinaldo C. Gonzales** has been named store manager, C-E's location, Anaco, Venezuela.

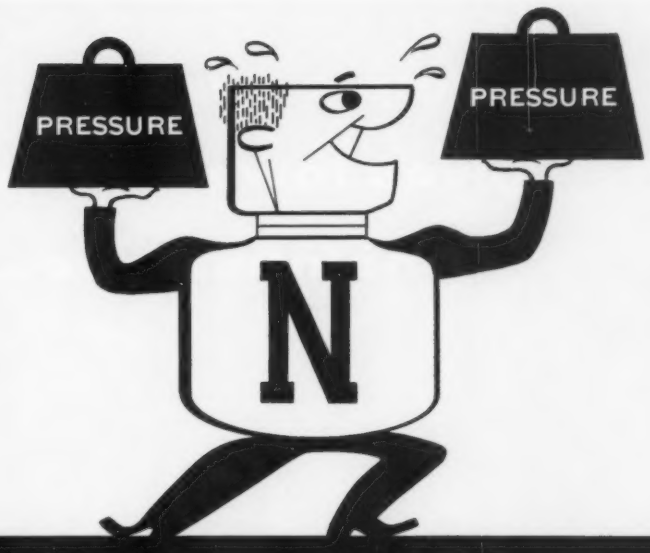
THE B. F. GOODRICH CO. has a new type of laboratory test wheel expected to speed development of new tire designs. The machine, being built for the company's Brecksville, Ohio, Research Center, will scientifically measure stability and steering response of tire.

PALL CORP. has named **Henry Petronis** vice president of manufacturing. He has been president of Glen Components Corp. since it was founded August 1958. He attended Columbia University where he majored in industrial engineering. Petronis will be in charge of all manufacturing operations of Pall Corp. and its subsidiaries and divisions in addition to being president of Glen Components.

Petronis

DIAMOND ALKALI CO. has appointed **Charles P. Egolf** assistant manager of the firm's Southeastern sales office, Memphis, Tenn. Egolf joined Diamond in 1953 as a field salesman. He graduated from Wesleyan College, where he received his B.S. degree in chemistry and biology.

UNITED STATES STEEL has named **Joseph B. Willmering** assistant manager of oil country tubular products, National Tube



True balanced vapor-pressure! That's why NICHOLSON STEAM TRAPS increase Thermal Efficiency . . . *and Here's How!*

When live steam contacts the bellows of a Nicholson Trap, the pressure inside the bellows equals the pressure outside. With both pressures balanced, the spring action of the bellows closes the trap. When condensate collects around the bellows, pressure inside drops causing outside pressure to compress the bellows and open the trap.

Briefly, this is true balanced pressure and is the operating principle of Nicholson Thermostatic Steam Traps. That's why they discharge condensate and air quickly, positively and intermittently . . . and why they help you get full thermal value from every pound of steam and full productive value from your steam equipment. They provide greater capacity, too . . . up to six times that of ordinary traps. And there's no steam waste either, because seats and valves are of hardened stainless steel, finely ground and accurately lapped for sure, tight shut-off.

As for maintenance, it's practically nil . . . and here's why. In this simply designed trap there is only one moving part. No links, pins, pivots or levers to go wrong. No adjustable orifices to stick, wear or become clogged. No need for valve and seat changing. In short, no downtime because of trap failure.

Naturally, plus efficiency like this does not come at "bargain" prices. You can get cheap traps, of course. But remember this: *price* only shows up on the dealer's shelf; *value* is what shows up on your lines . . . and with Nicholson Traps it shows up in discharge action you can rely on to keep temperatures high and even for full thermal efficiency at point of steam use . . . efficiency that can often increase production as much as 20%.

This is low trap cost, where it really counts. Let's tell you more.

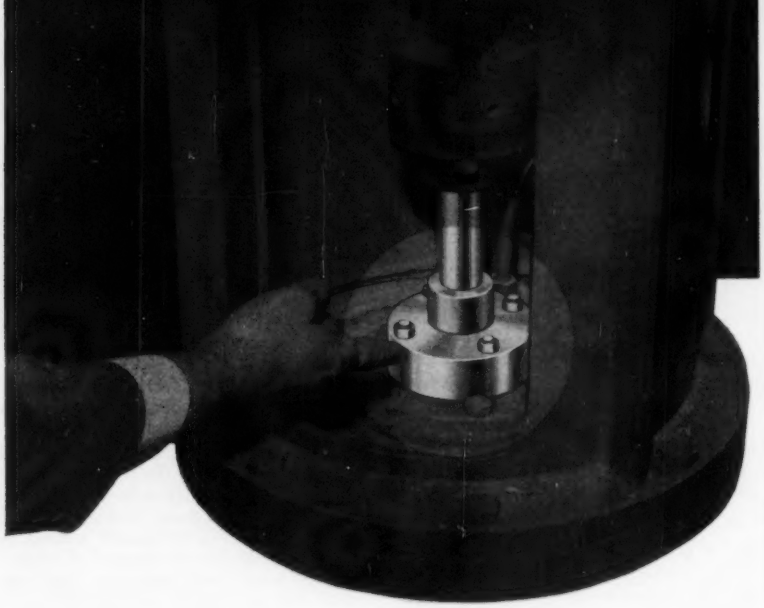
W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.
Offices in principal cities

Send for Catalog

W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.
Please send a copy of Catalog #400
NAME_____
COMPANY_____
STREET_____
CITY_____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

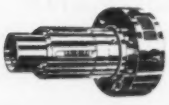
this simple seal gives lowest pump maintenance...

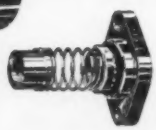


Save up to 66% of the time—expensive downtime—needed for installation or service of other mechanical seals used in plant process equipment.

The simple, effective Borg-Warner Type U Seal has no set screws—no close spring tension adjustments. It's fast and reliable.

For plants with a wide variety of pump service requirements, a minimum inventory of parts, and an easy change of gaskets adapts the Type U seal for service at temperatures of from —100 below zero to +650°F, and for pressures from 0 to 1000 psi.





Backed by Borg-Warner and proved in service, these dependable seals give complete safety, even in unattended stations.

Send for the latest Type U Seal engineering information—there's no obligation.

A PRODUCT OF B·W BORG-WARNER

Borg-Warner Mechanical Seals

P.O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

Suppliers . . .

Division. Willmering has been with the tube division for 38 years. He started with the division in the St. Louis district sales office in 1922. He was appointed special products sales supervisor in 1941.

Chehak

Luber

LINK-BELT SPEEDER CORP. has appointed **N. V. Chehak** and **M. P. Luber,** both vice presidents, to the company's board of directors, and **F. J. Strnad** vice president and chief engineer. Chehak has been with the firm 12 years. He attended Iowa State College, graduated from the University of Wyoming and served with three different construction companies before coming to Link-Belt. Luber started with the company in 1946 after working in construction and engineering during World War II. He is a graduate of Iowa State College. Strnad came to Link-Belt in 1945 after 11 years at Link-Belt Speeder, Chicago.

Strnad

WILLIAMS BROS. CO. Tulsa, is joining with the Panama Canal Co., a U.S. government agency, for the widening of a portion of the Panama Canal. The work will be done in the Empire Reach area, and entails the removal of about 7,300,000 cubic yards of earth and rock.

GOODRICH-GULF CHEMICALS INC., has appointed **Richard C. Shower** cost and economics analyst. Shower came to Goodrich-Gulf after five years with the B. F. Goodrich Chemical Co., where he was technical foreman of the synthetic fiber pilot plant.

EASTMAN CHEMICAL PRODUCTS, INC., Kingsport, Tenn., has named **John H. Sanders** sales manager of the Chemicals Division. Sanders was a regional sales manager in the E. C. P. I. Chemical Sales Division in Cleveland.

SAMUEL MOORE & CO., extruders of plastic products for industry, has announced a 70 percent plant expansion. This is the sixth expansion since the company moved to Mantua, Ohio, in 1947.

For more data on advertised products, use Readers' Service Cards, last page.

Trainees using Rockwood Double Strength FOAM liquid learn one of the most effective fire-fighting techniques ever developed. Training cost is low because 3 gallons of FOAM provide 1,000 gallons of extinguisher.

Training men with Rockwood FOAM costs you least, saves you most

Rockwood Double Strength FOAM liquid gives you more efficient fire protection at lower cost than any other fire extinguishing agent. By mixing only 3 gallons of FOAM liquid with 97 gallons of water and 900 gallons of air you get 1,000 gallons of a powerful fire-fighting mixture — *the cost of which, per gallon, is only three tenths of 1% of the cost of FOAM.*

Double Strength FOAM liquid helps you improve and economize your departmental training too. The very small proportion required to produce this extinguishing agent permits training under actual fire conditions at negligible cost.

For further facts on Rockwood Double Strength FOAM, tested and listed by Underwriters' Laboratories, Inc., send coupon today.

ROCKWOOD SPRINKLER DIVISION

of The Gamewell Company • A Subsidiary of E. W. Bliss Company

Engineers Water... to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD SPRINKLER DIV.
of The Gamewell Company
A Subsidiary of E. W. Bliss Company
Portable Fire Protection Division
482 Harlow Street
Worcester 5, Massachusetts

Please send me your illustrated booklet on Rockwood fire-fighting products.

Name _____

Title _____

Company _____

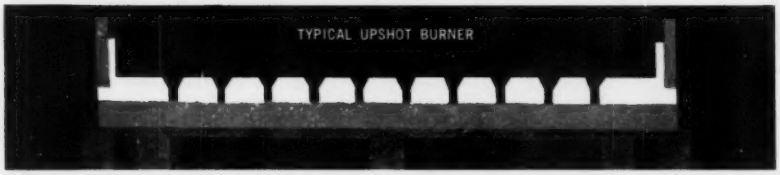
Street _____

City _____ *Zone* ____ *State* _____

For more data on advertised products, use Readers' Service Cards, last page.

Kaiser Purocast castable is a better refractory material than you can normally buy in factory-fired burner blocks. Carefully blended low-iron, high-purity ingredients give it high resistance to spalling. Its high density—140 pounds per cubic foot—effectively reduces corrosive slag penetration.

The characteristic volume stability of Purocast makes it particularly suitable for high temperature burner blocks in the refinery oil heater.



Ask your Kaiser Refractories Sales Engineer how you can make all of your own burner blocks with Purocast—in your plant—and get these advantages:

Longer life without failure. Good uses of unassigned manpower to cast blocks in advance. Reduced inventory. Freight savings. And assurance that you can replace any shape block 24 hours after pouring—regain full heating in as little as 48 hours!

Call or write Kaiser Refractories & Chemicals Division, Dept. P6011 Kaiser Aluminum & Chemical Sales, Inc., at any of the offices listed below:

KAISER REFRACTORIES

PITTSBURGH 22, PA. . . . 3 Gateway Center
MEXICO, MISSOURI . . . Mex-R-Co Building
OAKLAND 12, CALIF. . . 300 Lakeside Drive

Mexico Refractories now merged with Kaiser Refractories

KAISER REFRACTORIES, DEPT. P6011
KAISER CENTER, OAKLAND 12, CALIFORNIA

Please send me information about Kaiser Purocast with instructions for casting and curing burner blocks

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Suppliers . . .

DOW CHEMICAL CO.'S Industrial Service Division has named **W. B. (Bill) Brown** sales manager of the products branch. Brown, a product manager in Chlor-Alkali sales at Dow's headquarters, Midland, Mich., will transfer to the Cleveland office of DIS. He will be responsible for organizing the field sales group and developing the sales potential. He joined Dow in April 1954 in technical service and development. He received his bachelor's degree in chemistry at East Tennessee State College and did graduate work in chemistry at the University of Tennessee.

Brown

ALUMINUM COMPANY OF AMERICA has appointed **R. L. Schmid, Jr.,** manager of industrial chemical sales. He was manager of Alcoa's branch sales in Baltimore. Schmid came to Alcoa in 1944 at its East St. Louis, Ill., plant as assistant manager, planning and service.

CORNING GLASS WORKS has named **Miss Evelyn F. Ballou,** Washington, winner of the 1960 Corning Award as the year's outstanding medical technologist in the U. S. Miss Ballou is administrative assistant, Histopathology Laboratories, and supervisor, Ophthalmic Laboratory, Armed Forces Institute of Pathology, Washington.

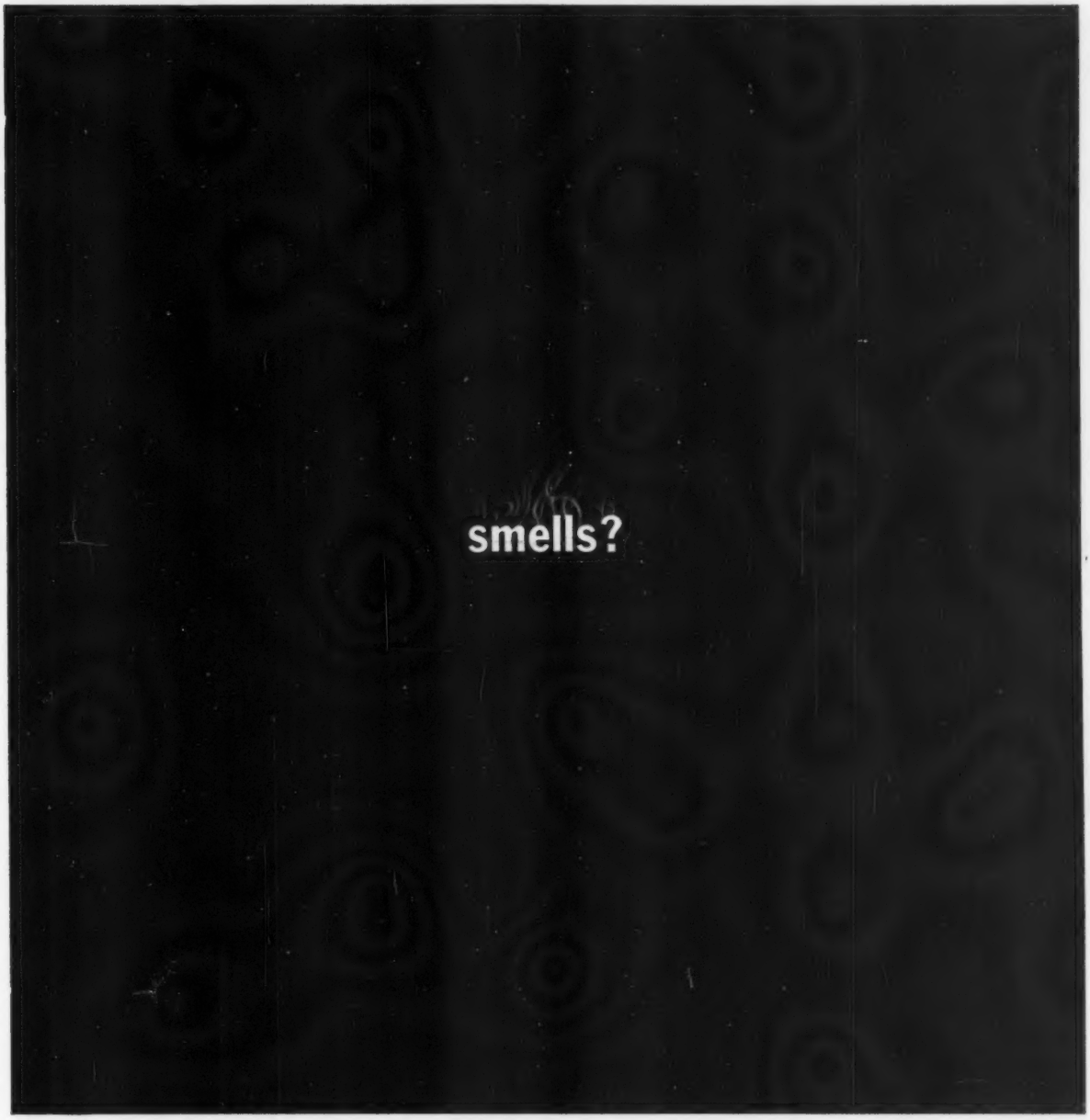
THE BABCOCK & WILCOX CO. has appointed **M. E. Ziegenhagen** director of advertising and public relations. He worked 12 years with the General Electric Co. and eight years as manager of public relations and advertising for the Worthington Corp. Ziegenhagen will make his headquarters in New York. He earned his B.S. degree in mechanical engineering from the University of North Dakota, and served in the U. S. Navy during World War II.

Ziegenhagen

BROOKS ROTAMETER CO. has changed its name to Brooks Instrument Co., Inc. Brooks, a manufacturer of flow measurement meters, has increased its sales volume by 40 per cent to date as compared with the same period last year.

HERCULES POWDER CO. has named **Robert Weir III** director of purchases. He came to Hercules in 1941 as a chemist at the Hopewell, Va., plant.

For more data on advertised products, use Readers' Service Cards, last page.



CALL ON RHODIA "ODOR ENGINEERING" TO SOLVE YOUR MALODOR PROBLEMS IN PLANT OR PRODUCT

Rhodia Inc. is the world leader in industrial odor control and reodorization technology and a primary producer of industrial aromatic chemicals. It offers fully qualified consultation service anywhere in the United States without cost or obligation.

Rhodia Alamask products are in use in virtually every industry to control malodor problems of stack gases, exhaust fumes, and plant effluvia effectively and economically. Rhodia "odor engineering" has also created greater market acceptability for wide range of finished products through the neutralization of unpleasant odors and/or the addition of pleasing and appropriate fragrances. Why not call or write Rhodia today about your problem, or use the coupon for additional information.

RHODIA INC. 60 East 56 Street, New York 22, N. Y. (Phone: PLaza 3-4850)

99-8

RHODIA INC.
60 East 56 St.
New York 22, N. Y.

Gentlemen:
Please send me Rhodia literature. My problem is:

(please give specifics)_____

_____

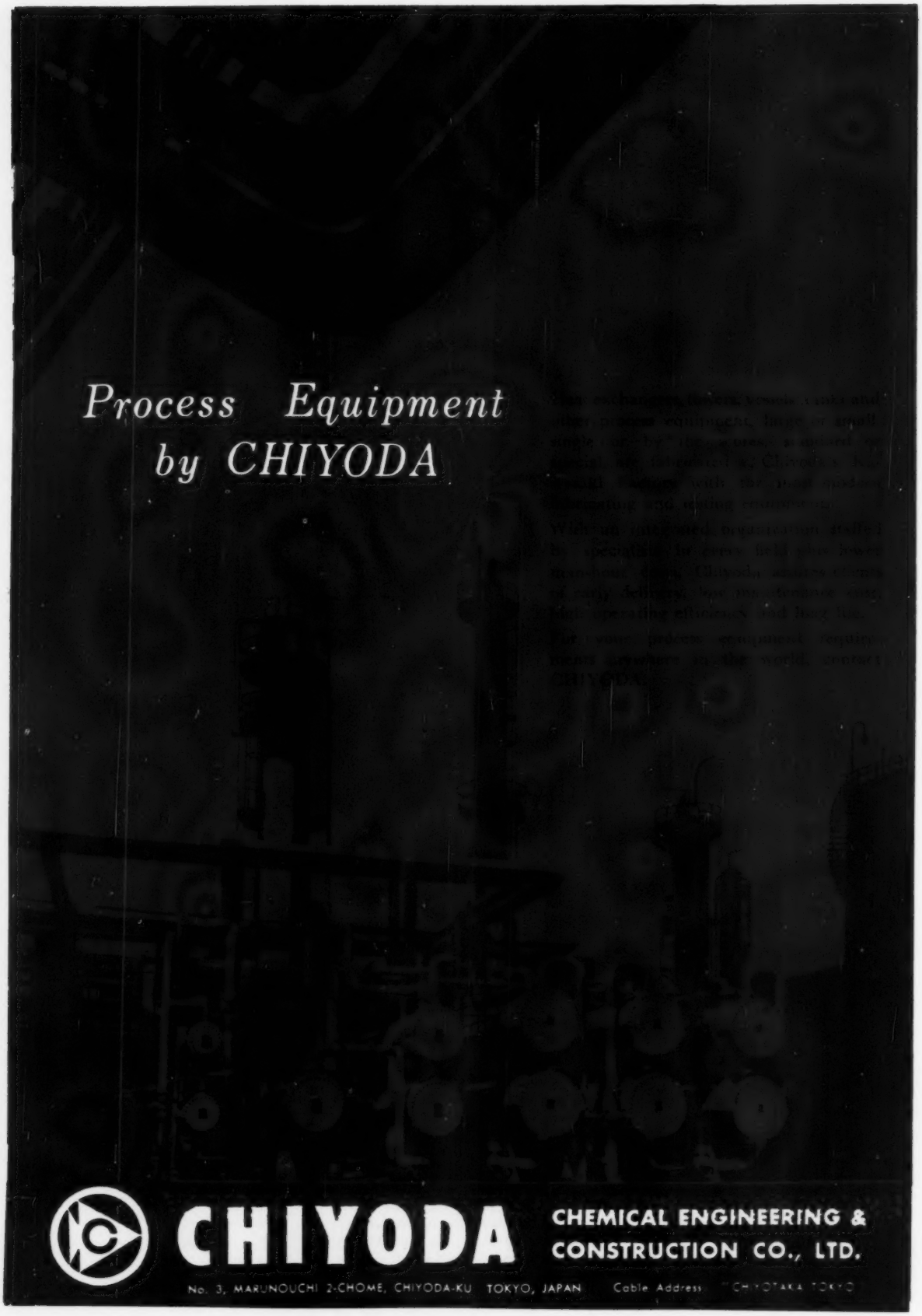
_____

NAME:_____

ADDRESS:_____

CITY:_____ STATE:_____

For more data on advertised products, use Readers' Service Cards, last page.



For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

THE DURALOY CO., Scottdale, Pa., has transferred **Henry Finger,** manager of production, to the Sales Department.

AMERICAN CYANAMID CO. has appointed **T. Dean Smith** manager of the Petrochemicals Department. Smith joined Cyanamid in 1946 as a production supervisor at the Bound Brook, N. J., plant.

Test Yourself

(Answers to Quiz on Page 151)

CASE NO. 1

A Board of Arbitration ruled: "Affording an employe an opportunity to make up improperly lost hours at a later date is not an adequate remedy. He is entitled to work those hours at the time they are available, not a later time more convenient to the employer. Furthermore, there always remains the possibility of termination of an employe between the time he is improperly denied available hours and the time when the employer decides to make additional hours available to him. The worker should be granted pay for the overtime he lost."

CASE NO. 2

The New York Supreme Court ruled: "There is no contract provision which confers on a union member the right to initiate an arbitration proceeding—and the union persuasively argues that the situation would become completely chaotic if each member of the union involved in a grievance complaint (of which there are thousands every year) could compel arbitration at the union's expense and contrary to the union's best judgment and wishes in the matter.

"Actually the union has shown that it has a very good reason for not proceeding to arbitration in this case, viz., that in a very similar case, which it finds is indistinguishable from petitioner's case, in which it did go to arbitration, it has recently received an adverse decision. Application denied."

CASE NO. 3

Arbitrator E. E. Hale, Chairman, ruled: "Call-in pay must be given if either of two situations occur:

1. An employe is called in to perform work outside his regularly scheduled shift.
2. The employe does that work at a time when he ordinarily would not be on the premises.

"Arbitrators generally are agreed that the purpose of call-in pay is to compensate an employe for inconvenience to which he is put or hardship he suffers or extra expense he may incur in being required to perform work outside his regularly scheduled hours and at a time when he otherwise would not be on his employer's premises. These men are not entitled to call-in pay."

HELP WANTED

HELP WANTED

TENNESSEE OIL REFINING COMPANY
a division of
TENNESSEE GAS TRANSMISSION COMPANY
has career opportunities for
SALES TECHNICAL SERVICEMAN

with 3 to 7 years experience who have received recognition by demonstrating outstanding abilities in the following area of Petroleum Refining:

Sales Technical Service—supervise control of product quality; product application problems; maintenance of product specifications.

Excellent working conditions, employee benefits and promotional opportunities. Please send complete resume covering personal data, educational and business background. All replies will be held in strict confidence.

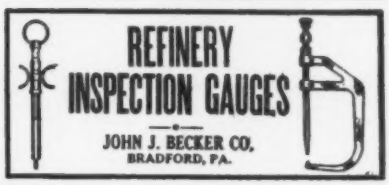
Industrial Relations Department
Box 2511 Houston, Texas

SENIOR PROCESS ENGINEERS

Permanent employment with an expanding company. Excellent advancement opportunities for men with at least 10 years experience in process design of petroleum and petro-chemical plants.

Send detailed resume to:
G. VICTOR HOPKINS
Arthur G. McKee & Co.
2300 Chester Ave. Cleveland 1, Ohio

FOR SALE



NOTICES - SERVICES

PETRO CHEM ESTIMATES

Professional Engineers—Members of American Association of Cost Engineers—Now performing a wide range of Cost Work in the Petro-Chemical Field, want to work with firm not requiring the full time services of experienced Cost Personnel. Reply to: ASSOCIATED COST ENGINEERS Box 339-R c/o PETROLEUM REFINER Houston, Texas.

Norman O. Eldred
Consulting Chemical Engineer
P. O. Box 3396, Mdse. Mart Postal Sta.
Chicago 54, Illinois
Complete Petroleum Refinery Design Engineering, Desalting, Fractionation, Catalytic Cracking, Thermal Cracking, Sweeting, Oil and Grease Blending and Packaging Plants, Bulk Gasoline and Oil Storage and Terminal Plants, Process, Finished Designs, Specs., Reports, Supervision.

FOR SALE

- Ortin Locomotive Crane 4 Cyl G.M.C. Diesel Engine 30 ton capacity—50 ft. Boom Air controlled—also 4 Cyl International Motor with Generator and controls attached for Light Plant or Magnet. Very reasonable—contact Southern Scrap Material Co., Inc. PO Box 1133, Baton Rouge, La.

Tear Sheets—Reprints

Handling costs compel Gulf Publishing Company to make a charge of 10 cents per page (minimum 25 cents) for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) is sent with the order.

Small, individual orders for REPRINTS of articles will carry a 50-cent charge per copy WHEN AVAILABLE. Cash (or company requisitions) must also accompany these orders. The $1. price on some of our larger reprints will, of course, continue to apply.

These price rules do not affect quantity orders (starting at 100 copies) of any article printed. Prices for these will be quoted upon request.

Address: Reprints,
Petroleum Refiner,
Box 2608
Houston 1, Texas

For more data on advertised products, use Readers' Service Cards, last page.

Recorder and Chromatograph For Fine Process Control

A new peak-picking recorder is being used in conjunction with gas chromatography equipment to increase the versatility of a trend-recording analyzer system for close control of process streams.

In the case of a petroleum refinery, for example, where crude oil is "cracked" to produce naphtha, kerosine, benzine, and gasoline, the system may be used to maintain a continual check on the breakdown process. The chromatograph sends the peak-picking recorder signals which are proportional to the quantity of each component detected. In turn, the recorder, a model 6707, records the peak heights of the individual components to provide a direct measure of their concentration, as well as identifying them.

The peak-picking recorder is especially well adapted to the gas chromatography system. If a single-point strip-chart recorder were used in such analysis, individual curves for each stream component would be readable only at fast chart speeds; as much as two or three feet of chart would be needed to log all components of a single sample. Since the operator using such a recorder can see only a small portion of the chart at any given time, he has trouble recognizing trends from one sample to the next in continuous process operations. The peak-picking recorder, instead, records only peak heights and the operator may study many hours of stream analysis in the recorder window at any given time.

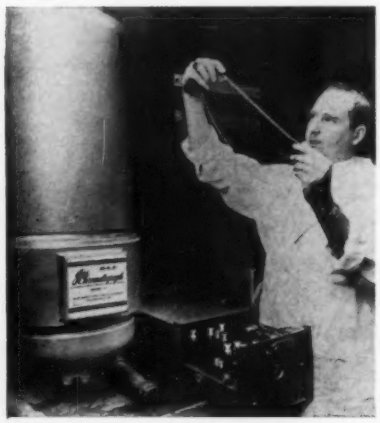
In operation, a memory unit in the analyzer stores signals for predetermined values while the timer shifts the chromatograph to the component to be analyzed. When the chromatograph completes its cycle and repeats the analysis, a new value is transmitted to the recorder. In this way, the system gives a continuous picture of the quantitative trend of each component. If the trend indicates that a process adjustment is required, the change is made immediately. By maintaining quality step-by-step throughout the process, a uniform end product is assured.

As further examples of use, the trend-recording analyzing system finds application in chemical plants for monitoring molecular ratios as in ammonia synthesis. In refineries it is used for polymerization and alkylation processes, and as a check on petrochemical feed and product streams in the production of ethylene, polyethylene, ethylene oxide, and ethylene dichloride. Weston Instrument Div., Daystrom, Inc.

Circle E1 green card, last page

Gas Chromatograph Gives Greater Process Control

A new gas chromatograph, utilizing tape programing to achieve greater precision and flexibility in automatic process control, employs a motor-driven transparent film in conjunction with a photoelectric transmitter and receiver to achieve any combination of time and sequence required to process



chromatography. The film is programed by graphite markings spaced to interrupt the photoelectric beam and effect such desired sequences as peak selection, range sensitivity, valve actuation, automatic zeroing of the detector cell, and visual read-out.

B&W
WELDING
FITTINGS

MADE BY MEN WHO KNOW
METALLURGY

B&W Welding Fittings manufacturing is integrated with the Division's facilities for research, development, product quality control and testing, as well as those for steel and tube-making. Take the relation between metallurgy and the manufacture of fittings. B&W not only knows fittings manufacturing, but is able to control, completely, all phases of the manufacturing process . . . starting with the melting of the steel. Integration plus metallurgical knowledge and practice makes for superior fittings. It enables B&W to provide a quality-controlled product, matched to end use service.

B&W Welding Fittings and Flanges are available through qualified welding fittings distributors in carbon steel and the B&W CROLOYS in a complete range of types and sizes. Write for B&W Bulletin FB-502. The Babcock & Wilcox Company, Tubular Products Division, Fittings Plant, P.O. Box 230, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA9080WF3

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more data on advertised products, use Readers' Service Cards, last page.

Equipment . . .

The accuracy of the tape-programed timing system is reported to be greater than conventional mechanical cam timers. Repeatability approaches one-tenth of a second.

The gas chromatograph also claims improved stability in column temperature, achieved by dual-temperature zoning within the analyzer housing. To insure against possible heat flow resulting from changes in ambient temperature, air is directed through the low-temperature zone and warmed when required by a finned heater governed by a balanced thermistor bridge system. The thermistor can sense changes in temperature as low as 0.3° F.

The high-temperature zone, with a range of 120° to 450° F, has a constant heat supply and is insulated from and located within the low-temperature zone. Temperatures in this zone can be held to 0.03° F.

The analyzer of the chromatograph can accommodate two columns up to 50 feet each in length. A motor-operated valve allows the two columns to be operated independently or simultaneously in either direction, with the option of using the two columns in series or in parallel.

A three-position function switch allows the operator to choose the preferred mode of chromatographic presentation. This can be a bar graph presentation in which trends in process stream components can be quickly monitored, or it can be a spectrum presentation of the complete chromatogram on the recorder chart. A third choice is manual operation, in which the automatic tape programer is stopped and the operator advances the sequence by depressing a push button. Mine Safety Appliance Co.

Circle E2 green card, last page

TRINITY

STEEL COMPANY, INC.

4001 IRVING BLVD. • DALLAS 7, TEXAS
FRANCESVILLE, INDIANA
WHEN IN MEXICO CITY, VISIT TANQUES de ACERO TRINITY, S.A.

DESIGN AND ENGINEERING

Trinity Steel's engineering department is adequately staffed and equipped to give you engineering service and liaison in all areas, from preliminary design of custom fabricated products — finished drawings — to shop supervision in guarantee of engineering standards.

FABRICATION FACILITIES

Trinity Steel has a successful record of fabrication in all steels under all codes, gained from many years experience in refinery and petro-chemical vessels. Inert gas shielded arc (tungsten and metal-electrode) welding techniques are used in conjunction with latest equipment for metal forming. The Dallas plant main fabrication building has over 72,000 square feet under one roof.

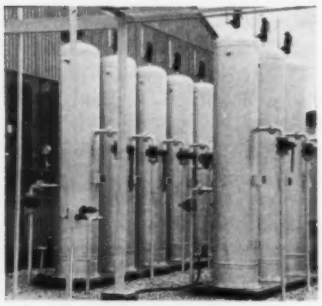
EXPERIENCE

Trinity Steel has been satisfying customer requirements since 1936. Situated in the heart-land of the U.S. refinery and petro-chemical industry, Trinity has grown soundly and competently through sound engineering combined with precision manufacture. Trinity products are shipped to countries world wide.

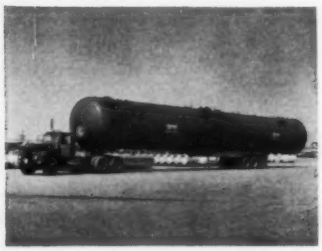
Whatever your specific requirements may be, you are invited to submit your request to us for detailed analysis. All estimates and recommendations are furnished without obligation.

ETHYLENE OXIDE TRANSPORT

STABILIZER TOWER



AIR RECEIVING TANKS



DEETHANIZER TOWER

Forged Steel Gate Valves Reduce Maintenance Costs

Precision-made forged steel gate valves to reduce maintenance costs are available for valve pipe sizes ranging from ¼ through 2 inches. Self-locking nuts on the handwheel and packing glands are stock size and are readily replaced if mislaid.

The handwheel features a built-in safeguard. Should excess torque be applied to the handwheel it will break before the valve is seriously damaged. Hexagon ends on the valve body facilitate installation.

To effect maximum seal the body to bonnet chevron form gasket is fully recessed in a chamber designed to prevent gasket blowout. Loss of gland bolts is stopped. When the gland nuts are loosened, the gland eye-bolts cannot be lost as they swing on pins connected to the valve bonnet. This type of gland bolt and a one-piece packing follower simplifies repacking the stuffing box.

One-piece bonnet construction results in lower valve height and a more compact over-all design. Shoulder-type seat rings are sized to afford free flow. They are expanded into the valve to ensure a positive seal. And the seating surfaces are hardened to provide maximum resistance to wear.

The strong stem has a long-sleeve thread engagement and the threads are not exposed to corrosion or sediment from line fluids. Penberthy Injector Ltd.

Circle E3 green card, last page

Process Analyzer Very Sensitive To Organics

The Pye Process analyzer is an industrial version of the well-tried Pye Argon Chromatograph.

The analyzer automatically draws a sample from a sample stream brought in pipes to the instrument; the frequency of this sampling is pre-set by the control unit. The sample is eluted through the packed column by the argon carrier gas and the components separated. A DC electrical signal is transmitted to the control unit as each component passes through the detector. An appropriate attenuator is automatically selected in the control unit for each component and the resulting signal transmitted to the recorder. The result of

1/2¢ Per Barrel Hydrotreating Catalyst

HARSHAW COBALT MOLYBDATE

Proven superiority where it counts—*long life* and *low cost*. Typical installations using Harshaw Cobalt Molybdate Catalyst and achieving catalyst costs of less than ½¢ per barrel:

a Hydrotreating cracked, high sulfur high nitrogen stock. Catalyst retained high activity through seven-plus years of service and 12 regenerations.

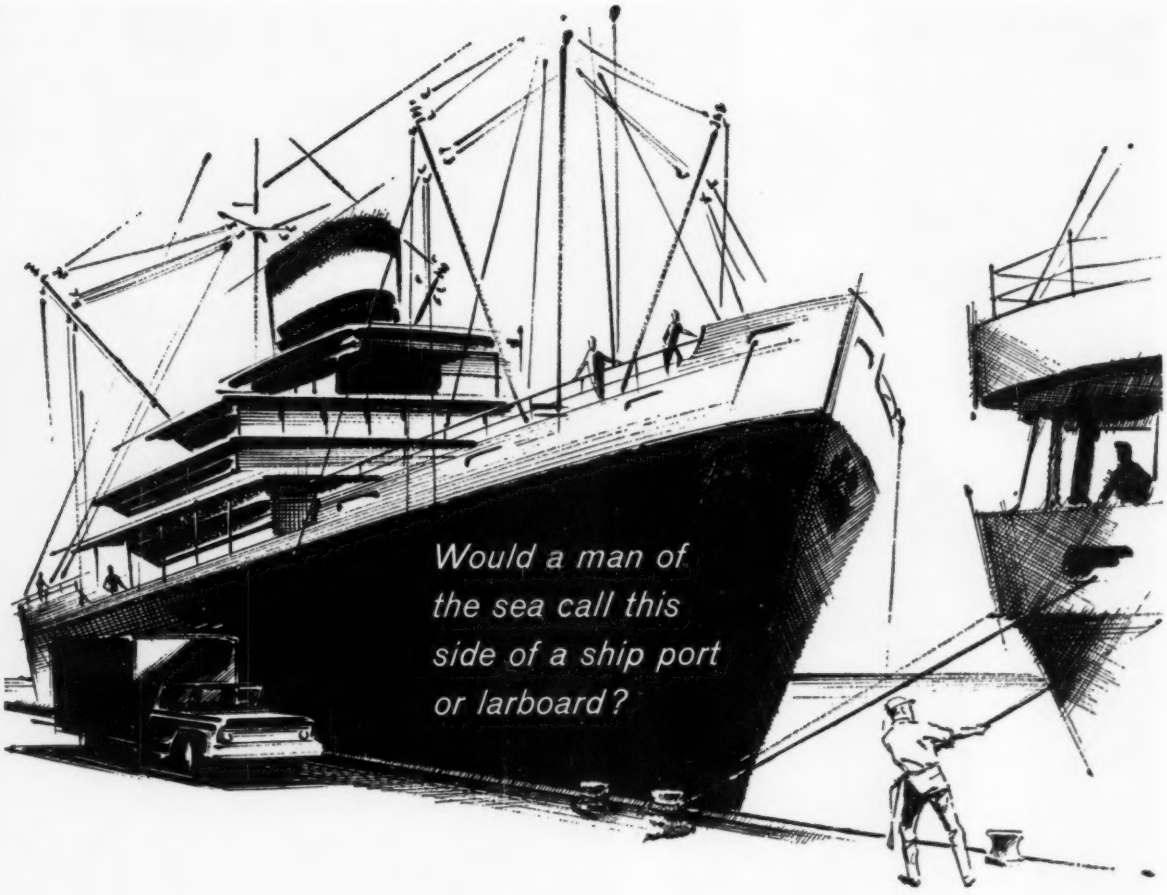
b Hydrotreating high boiling straight-run diesel oil. A feed rate of 2½ times without regeneration of the catalyst—and still going strong.

Active, supported, and thermally stable, Harshaw Cobalt Molybdate Catalyst proves its superiority where it counts—with long life and resulting low cost. It can give you the type of performance cited above with any feedstock from low boiling naphthas to heavy residual distillates. In all applications it has long life of one catalyst charge per year per barrel capacity. For further information about this and other proven hydrotreating catalysts, [illegible]

THE HARSHAW CHEMICAL CO.

1945 E. 97th Street • Cleveland 6, Ohio

For more data on advertised products, use Readers' Service Cards, last page.



Can you tell the real thing when you see it?

This much about water-borne vessels is clear: They carry their cargoes at low cost.

Can you take advantage of this fact? We ship liquid caustic by barge from our Michigan and Louisiana plants. We know that many caustic users who should be receiving barge shipments aren't doing so. If you are situated near a navigable waterway, you may be one of them. We'd like to help you find out.

Call on us for caustic by barge . . . or truck, or tank car. An analysis of your position is part of the package.

Wyandotte offers a number of chemicals for the petroleum industry, including materials for drilling muds, gas dehumidification, demulsifying, emulsifying, secondary recovery, water treatment, cementing, sweetening, and many other petroleum, refinery, and petrochemical applications. Get full details from your distributor, or write: *Wyandotte Chemicals Corporation, Wyandotte, Michigan. Also Baton Rouge, Louisiana. Offices in principal cities.*

ANSWER: Neither. This is the right-hand or *starboard* side of the ship. The left side, which was once called *larboard*, is now called *port*.

* * * * *

WYANDOTTE CHEMICALS
MICHIGAN ALKALI DIVISION
Pacing progress with creative chemistry®

the analysis appears as a series of separated peaks whose heights are proportional to the concentration of the individual components in the sample. Alternatively, individual peaks may be selected or a bar presentation made. An external alarm circuit may also be energised when a particular component emerges.

This system is very sensitive to organic materials: it has been used to give a full scale response of 5 ppm acetylene in an air sample with a limit of detection of less than 0.05 ppm acetylene. The system may also be operated satisfactorily when the components of the sample are in the percentage range.

The Argon Ionisation Detection System is suitable for the measurement of any sample component with an ionisation potential of less than 11.8 E.V. (the excitation energy of the metastable argon in the detector). This includes almost all volatile organic materials except methane; it excludes permanent gases. W. G. Pye & Co., Ltd.

Circle E4 green card, last page

Safety Relief Valves For 300/psi Service

A new series of safety-relief valves for refinery and chemical processing service provides precise blowdown ring control for gases and vapors, and safety relief for liquids in a wide range of applications where maximum pressure is 300 psi.

The 1870 Series has a one-piece stainless steel body and stainless steel disc which contains inlet pressure without other joints or gasketing. This one-piece stainless steel construction provides a leak-proof seat that eliminates waste and corrosion problems.

The valves are available with tungsten steel springs for temperatures up to 800°F. Choice of plain cap, packed cap and lever or open lever. Inlet connections include male screwed or 150 and 300-psi raised-face flange types. Flanged valves have full RF diameter. Farris Engineering Corp.

Circle E5 green card, last page

Silica-Magnesia Catalyst For Fluid Cracking Units

SM-30 is a new stabilized silica-magnesia catalyst for petroleum fluid cracking units containing approximately 28 percent magnesium oxide. It has undergone thorough laboratory and pilot plant testing, and a commercial trial is expected before the end of the year.

The tests have shown that as compared with 13 percent silica-alumina catalyst, the new product can be expected to give higher yields of gasoline and furnace oil; lower yields of coke, light gases and residual fuel, and higher effective activity maintenance, with the thermal stability and regenerability required by current fluid catalytic cracking units.

This flexibility of yield which the silica-magnesia catalyst can contribute to refineries, without the need for costly investment in additional processes, is expected to commend its use in many typical situations.

The announcement points out that it has become apparent that no one or two types of catalysts can completely satisfy the different requirements that now exist within the petroleum industry. There are refineries which must obtain maximum production of light gases for use as petrochemical feed or as charge to alkylation or polymerization units. But there are also diametric opposites, where the production of light fuel oils is more important.

There are refineries in which the fluid catalytic cracking unit must be operated for maximum octane production, but there are those also in which other processes have reduced the octane load on the fluid unit. There are refineries where residual fuels have value; others consider residuals a burden.

For some time the potential value of a silica magnesia catalyst to satisfy the need for real flexibility with regard to relative production of light fuel oil vs. gasoline and

When
is oil
really pure?
When it's been filtered through FLOREX® fuller's earth or FLORITE® activated bauxite. Whether you use percolation or contact methods, these two quality adsorbents will clarify and decolorize your feed stock; refine and stabilize it. Contaminants both in solution and suspension are efficiently removed by FLOREX and FLORITE.
Each grade of FLOREX and FLORITE has the same uniform high adsorptivity. Uniform grain size and screen distribution are maintained shipment after shipment.
Why not find out how to purify your feed stocks . . . using FLOREX or FLORITE? Let our Customer Service Laboratory show you the advantages of using these two quality mineral adsorbents. There is no obligation.
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Fuller's Earth • Activated Bauxite • Synthetic Adsorbents
Sales Offices: P.O. Box 989, Tallahassee, Florida; 375 Park Avenue, New York 22, N.Y.; 8000 Bonhomme Avenue, St. Louis 5, Mo.; 292 Meadows Bldg. Dallas 6, Texas

Jefferson Gas Processing Specialist makes a house call on ailing refinery

Your refinery engineers have already diagnosed your gas sweetening ailment . . . contaminants that are causing either corrosion, neutralization of solution, foaming, or a combination of detrimental results. Pinpointing the cause and cure remains. Here, Jefferson Chemical's Gas Processing Specialist can help.

He is no Merlin. His procedure is to sift and evaluate all pertinent data with your engineers. He will review such factors as the composition of the gas to be treated, the percentage of hydrogen sulfide and/or carbon dioxide in the gas and final purity desired; your choice of amines and solution strength; solution circulation rate which depends on quantity, temperature and pressure of the gas treated; operating conditions for absorption and reactivation. Often your problem, with specimen solutions, is referred to Jefferson's Austin Research Laboratories for analysis and study. This coordinated probing, plus Jefferson's vast fund of case experiences, will help you arrive at the best remedial action to minimize costly corrosion and solution contamination.

When you have a knotty gas sweetening problem, call in the Jefferson Gas Processing Specialist. He can provide prompt technical services plus ethanolamines in the quantity and purity you need . . . Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

Ethylene and Propylene Oxides, Glycols, Dichlorides, Carbonates
SURFONIC® Surface-Active Agents • Ethanolamines • Morpholine
N-Alkyl Morpholines • Polyethylene and Polypropylene Glycols
Piperazine • Piperazine Salts • Nonyl Phenol • Caustic Soda

HOUSTON • NEW YORK • CHICAGO • CLEVELAND • CHARLOTTE • LOS ANGELES

JEFFERSON CHEMICALS

light ends has been appreciated, but there have been difficulties in designing a commercially practical product. Davidson Chemical Div., W. R. Grace & Co.

Circle E6 green card, last page

Digital Computer Features High Speed Computation

A completely integrated computer control system, the Honeywell 290 digital computer, is a general-purpose, all-solid-state device specifically designed for process applications and incorporating, the company said, "major advances in computer technology."

Typical operating rates of the computer are 8,000 additions or subtractions, 1,250 multiplications, or 400 square root extractions per second including memory access

time. Both binary and decimal arithmetic are used by the computer.

For on-line monitoring and control of industrial processes the high-speed permits frequent system checks and closer control of process variables. It also enables the computer to do other jobs on a time-sharing basis and provides for future increases in scope and complexity of operations.

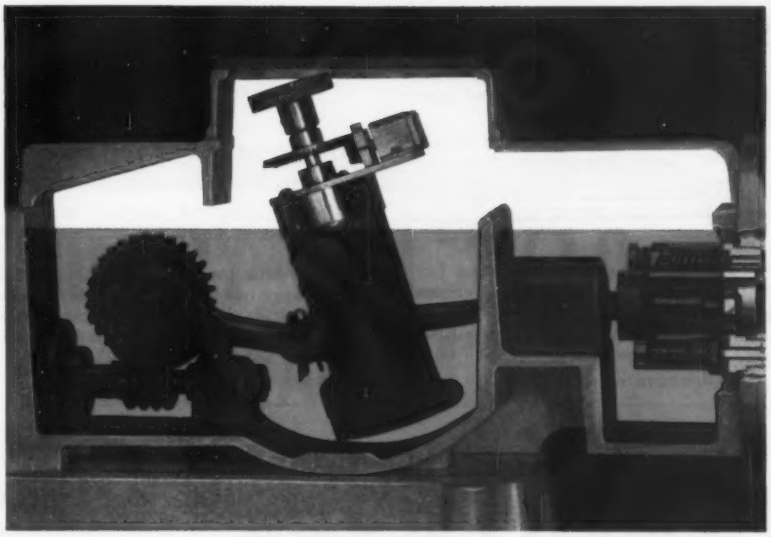
"Building block" construction is shown in the plug-in drawers containing solid-state circuitry. Minneapolis-Honeywell Regulator Co.

Circle E7 green card, last page

Two Studs Connect Tubeside Double-Pipe Heat Exchanger

A low-cost, double-pipe heat exchanger, with greatly amplified assembly and disassembly and maintenance features requires only two ¾-inch alloy steel studs each on the tubeside connection and the tubeside closure.

Economies are further obtained by a simplified hammer lug design which locks the head to tube closure into place by means of one large forged-hammer type nut. The hammer ring is easily acces-



This is why you never heard of a PULSAFEEDER wearing out!

Every moving part of every Lapp Pulsafeeder Metering Pump is completely submerged in oil. This total lubrication reduces friction to practically the theoretical minimum. And there's no possibility of corrosion from exposure to atmosphere.

For year after year of *extra* service life, Lapp Pulsafeeders continue to give you the exclusive advantages for which you bought them. Advantages like complete freedom from leakage and contamination; precision metering, at flow rates from a few drops to 15.7 gallons per minute; pressures up to 7000 psig; choice of heads for safe handling of acids, abrasive slurries, radioactive fluids; manual or instrument controls, We've got a new catalog to help you fit the right model to your process.

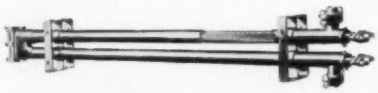
Lapp

***WRITE** for Catalog 59. Lapp Insulator Co., Inc., Process Equipment Division, 1508 Poplar Street, LeRoy, N. Y.*

For more data on advertised products, use Readers' Service Cards, last page.

sible from the front end which makes the unit easier to disassemble whenever inspection is required.

The units are so designed that the tube



element can be pulled straight out from the shell. There is no need to disconnect any tubeside piping—just the easily accessible studs making up the tubeside joint need be removed.

Misalignment of shell inlet and outlet connections is eliminated because the shell nozzles are integral with the shell. Brown Fintube Co.

Circle E8 green card, last page

Data Logger Evaluates Process Performance

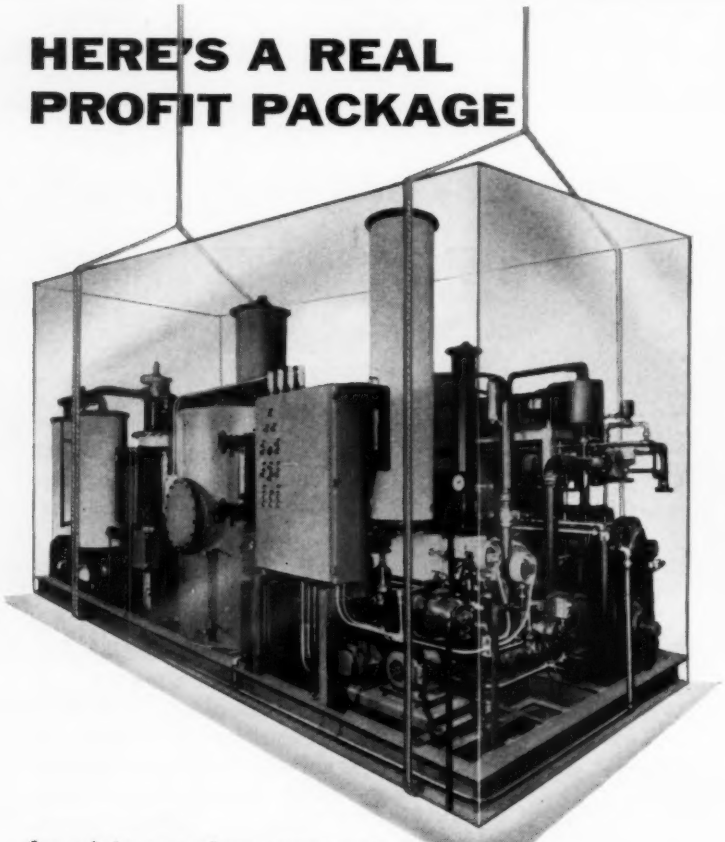
Utilizing advanced concepts in solid-state electronics and practical design, the new Model PDL-1 Process Data Logger provides data for evaluation of process performance in refineries and petrochemical plants. It is a highly efficient and reliable analog/digital conversion system for recording signals received from transducers attached to vital process functions. Translated signals can be pneumatic, electrical or mechanical.

The PDL-1 is also used for gathering data needed to make necessary system improvements, such as re-arranged instrumentation, which will improve over-all process efficiency and profitability.

Appropriate linearization circuits, thermocouple reference junctions, zero suppression and scale factoring networks, plus all necessary power supplies are provided in the console. Data can be printed out as 3 or 4-decimal digits. Southwestern Industrial Electronics Co.

Circle E9 green card, last page

HERE'S A REAL PROFIT PACKAGE



for minimum volume gas users . . . a single base, completely packaged gas generator that will produce all the gas you want, when you want it, at lowest possible costs. Even minimum gas users have found they can amortize the cost of an efficient Gas Atmospheres system over a few short months.

Gas Atmospheres builds factory assembled and tested packaged units for the production of reducing, nitrogen, carbon dioxide, hydrogen, inert and annealing atmospheres for use in the metal, food, petroleum and chemical industries—from 50 cfh to 50,000 cfh. If you use gas why not make certain you have the most efficient operation possible. Call in your Gas Atmospheres engineer today or write direct to *Gas Atmospheres, Inc., 3855 West 150th Street, Cleveland 11, Ohio.*

THE NATION'S LARGEST MANUFACTURER OF PACKAGED GAS GENERATOR SYSTEMS

gas Atmospheres, inc
3855 West 150th Street • Cleveland 11, Ohio

Coating Is Cheap, Easy To Apply And Non-Hazardous

Pfaudlon 301, a new sprayable coating of Penton in water-suspenson, can be applied to desired thickness 20 to 40 mils) with as few as two applications while four or more are commonly required when alternate methods are used. Additionally, (1) parts do not require preheating as in existing dry-coating techniques, (2)

complex shapes can be easily covered; and surfaces not requiring the coating can easily be excluded, (3) a superior bond is obtained between the metal surface and the resin.

The coating has almost universal resistance to corrosion at temperatures to 250° to 275° F, and resistance to abrasion and impact damage is excellent. The Pfaudler Co.

Circle E10 green card, last page

Mechanical Seal Details Described In Booklet

A new booklet describes the engineering and application of the compact, ready-to-install Mechanipak seals.

Well illustrated with sectioned and lined drawings, the bulletin outlines temperature, pressure, shaft speed and other critical operating information necessary when selecting or utilizing mechanical sealing devices. Two handy tables are in-

For more data on advertised products, use Readers' Service Cards, last page.

YOUR REFINERY WILL YIELD MORE WITH CYANAMID'S FLUID CRACKING CATALYST COMPOSITION

AEROCAT® 3C

THREE COMPONENT CATALYST

MORE GASOLINE OR MORE PROPYLENES, MORE BUTYLENES Cyanamid, in co-operation with a major oil company, has developed AEROCAT 3C—a new fluid cracking catalyst composition. AEROCAT 3C gives refiners more flexible and profitable operations and a greater yield at the expense of dry gas and coke. AEROCAT 3C-12 for increased gasoline yield. AEROCAT 3C-20 for increased propylene and butylene yields. **BASIC IN CATALYST CHEMISTRY**

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

Equipment . . .

cluded, one listing standard sizes of seals which are currently available and the other detailing the type of construction of various seals together with the standard and optional features available. Examples of typical applications and several engineering specification forms are included in each bulletin. Garlock Inc.

Circle E11 green card, last page

Laboratory Equipment Catalog Cross-Indexed

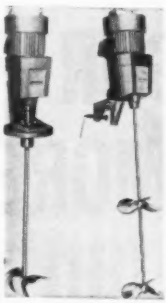
A new laboratory supply catalog features completely alphabetical arrangement of products for faster, easier finding. Cross-indexing further helps users find everything from a test tube brush to a spectrophotometer. Items are briefly and accurately described and illustrated, to save time in ordering.

Concise wording and compact arrangement keeps this complete catalog small enough for easy handling. All new, the catalog includes section on: Gas Chromatography, Environmental Equipment, Laboratory Presses, Tensile Testing Equipment and Glassware Washers. Wilkens-Anderson Co.

Circle E12 green card, last page

Portable Mixers Offer Better Mixing Efficiency

A completely new line of Lightnin propeller-type portable mixers for fluid agitation in process industries have been designed as an integral unit. The new mixer offers increased mixing efficiency, improved handling convenience, and maintenance-free operation. It will be marketed in sizes ranging from 1/8 hp to 3 hp, and will also be available in a fixed mounting design in all except 1/8-hp sizes.



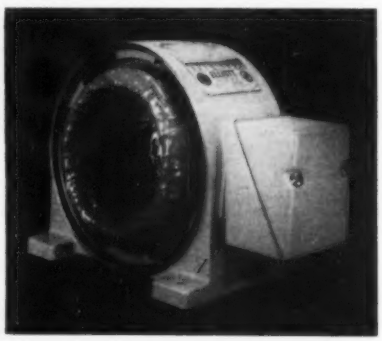
The mixers offer not only direct-drive speeds of 1,750 rpm and 1,150 rpm with higher impeller heads, but also a gear-drive model speed of 350 rpm providing up to 45 percent more flow than previous units. Gear-drive models are quiet running, leak-proof, and equipped with single reduction, internal helical gears for compact drive, additional strength, and improved gear life. Both direct and gear-drive models rotate clockwise.

A unique feature of the series is its exclusive, positive drive chuck, permitting fast, accurate coupling in one simple operation. Its location is always above the maximum fluid level of the mixing tank. A flat on the mixer shaft insures a positive grip and correct position with each shaft insertion. Mixing Equipment Co., Inc.

Circle E13 green card, last page

Insulated Motor Runs 1,000 Hours Under Water

A new epoxy insulation system for electric motor coils, known as Epa-Seal, is applied to both random-wound and form-wound motors of 1 to 500 hp. This is believed to be the first time that this epoxy



insulation has been offered in motors of the higher horsepower ratings.

For form-wound motors, Epa-Seal epoxy resin is applied to core and frame before winding. Slot cells are epoxy-glass, and coils are covered with glass tape, with slot sections protected by epoxy-mica wrapper. After all coils are installed, the

A RECORD CLIMBING TO THE TOP

the KEMCO code / ***THOROUGH QUALITY CONTROL INSPECTION***
SPECIFICATIONS MATCHED EXACTLY
DELIVERY WHEN PROMISED

We'd like to furnish you more information. Please write today for illustrated brochure and additional data on personnel, facilities and customers to:

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"MANY HAPPY RETURNS"

This Class 600 Marley Double-Flow cooling tower is one year old . . . and in excellent condition functionally, mechanically and structurally. To assure many more "happy" anniversaries over a long future, The Marley Company will never relax vigilant attention to every detail of its welfare.

Like all Class 600 towers, it will be under the surveillance of a member of the Marley Service Engineering staff, experts on cooling tower operation and maintenance. The results of their services are best attested by supervisory engineers and executives in plants where Class 600 towers are now in service:

ENGINEER, GENERATING STATION:

"We have greatly appreciated the service you have rendered. We had little experience with towers before these four units were put in operation, but we have received much help from your service engineer. Periodic inspection by someone who knows towers relieves us of the worry of letting our towers degenerate. Our supervisors always look forward to these visits and have plenty to discuss with your engineers. Your service has been good and we hope we can continue along this way with the new tower which you will soon be building here."

MANAGER, NUCLEAR PLANT:

"It is our opinion that mutual benefit has been derived from the periodic visits of your service engineer. We know that this service has given us experienced assistance in operational, mechanical and wood deterioration problems."

REFINERY ENGINEER:

"The Marley service engineer has been a most helpful person to work with and has always been ready to come and help us. His recommendations have been fair, honest and unbiased. That is why we have always accepted them. We would be very disappointed if this service was not available; we have come to depend on it."

MUNICIPAL POWER SUPERINTENDENT:

"From the power plant operator's point of view this is the best service you can give! I will welcome your service engineers at all times. There are many pieces of equipment in a power plant and it is impossible to give each piece of equipment the loving care that the manufacturer would like it to have. Therefore, I welcome an opportunity to discuss, with service engineers, the operation and maintenance of any piece of equipment in the plant. Your service engineers have been most courteous and helpful. I hope that I shall see more of them in the future."

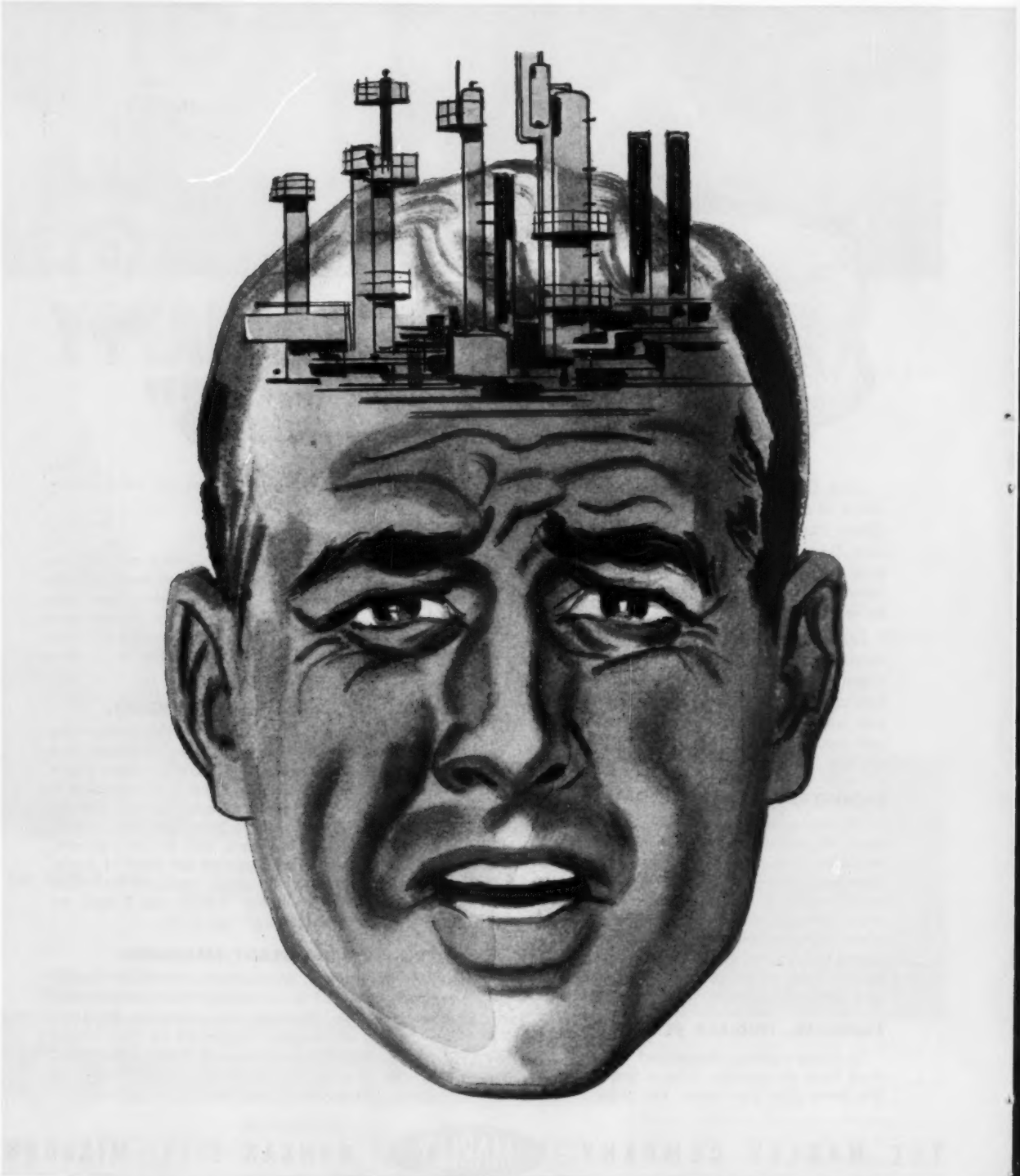
PETRO-CHEMICAL PLANT MANAGER:

"We have found the attention of Marley service engineers beneficial to our cooling tower operation and maintenance. In particular, we appreciate the latest inspection of our towers. This service has been helpful to our preventive maintenance and cooling tower repair programs. We are looking forward to working with your engineer during an early visit."

THE MARLEY COMPANY MARLEY **KANSAS CITY, MISSOURI**

For more data on advertised products, use Readers' Service Cards, last page.

Kellogg Cures Sulfur Headaches



For more data on advertised products, use Readers' Service Cards, last page.

with Low-Cost Hydrotreaters

KELLOGG-DESIGNED UNITS REDUCE CORROSION, INCREASE CATALYST LIFE AND SELECTIVITY, IMPROVE PRODUCT QUALITY WITH LESS TEL

With less low sulfur crude available today, and product specifications increasingly difficult to meet, a Kellogg hydrotreater is the refiner's answer to the many refining, storage and marketing problems presented by high sulfur-content feedstocks.

Working closely with the refiner's engineers, as it has done with those of leading oil companies throughout the United States—as well as in Canada, South America, Europe, Asia and Australia—Kellogg can design a unit that will remove harmful sulfur compounds to almost any degree desired, and also permit decrease of TEL.

Optimum investment and operating costs are also assured through designs that utilize selective pressures, reduce the use of costly alloys such as 18-8, and lower the consumption of high pressure hydrogen.

A Record in Desulfurization

To date, as shown at right, Kellogg has engineered and/or erected 17 reformer feed hydrotreaters—with a total capacity of over 161,000 BPSD, and 13 distillate hydrotreaters—with a total capacity of over 164,000 BPSD.

To acquaint you further with desulfurization by hydrotreating, Kellogg will gladly send you copies of a recent paper written by two of its engineers and reprinted from "Petro/Chem Engineer."

THE M. W. KELLOGG COMPANY
711 Third Ave., New York
A subsidiary of Pullman Incorporated
Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

REFORMER FEED DESULFURIZERS	
Heath, Ohio	3,000 BPSD
Houston, Texas	24,000 BPSD
Bakersfield, Cal.	4,000 BPSD
Kent, England	10,000 BPSD
Grand Prairie, Alberta	875 BPSD
Antwerp, Belgium	2,500 BPSD
Toledo, Ohio	22,000 BPSD
Ponca City, Okla.	16,000 BPSD
Dunkerque, France	10,000 BPSD
Lemont, Ill.	18,000 BPSD
Vancouver, B.C.	7,200 BPSD
Kwinana, Australia	10,000 BPSD
Montevideo, Uruguay	3,000 BPSD*
Concon, Chile	6,000 BPSD
Dinslaken, Germany	10,000 BPSD*
Antwerp, Belgium	10,000 BPSD
Turkey	4,600 BPSD*
DISTILLATE DESULFURIZERS	
Kwinana, Australia	5,600 BPSD
Port Arthur, Texas (2)	45,000 BPSD
Philadelphia, Pa. (2)	45,000 BPSD
Martigues, France	12,500 BPSD
Kent, England (2)	20,000 BPSD
Antwerp, Belgium	10,000 BPSD
Clarkson, Ont.	8,000 BPSD
Vancouver, B.C.	4,000 BPSD
Dinslaken, Germany	10,000 BPSD*
Turkey	4,500 BPSD*

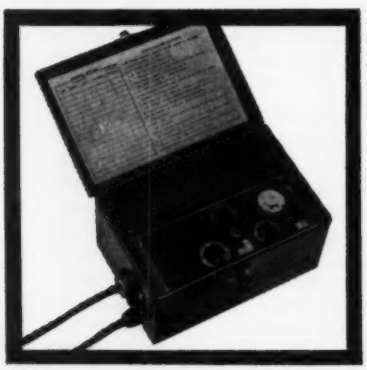
**Future*

ELLIOTT air magnetic tube expander drives

automatically controlled for fast, accurate tube rolling

Designed for faster, precision tube rolling, the standard model Elliott Air-Magnetic drive is setting new records for speed and accuracy. Some operators average 12 tubes per minute. Desired torque easily preset by rotating forward end of unit. No tools needed. Rolling stops when preset torque levels are reached. Includes trigger-controlled, explosion-proof air motor in single unit. Magnetic control, no springs. Balanced for easy handling. For tubes ¼ in. through 3 in. *Standard model* handles most jobs. *Heavy-duty* for higher torque.

ALSO Electric Control ... Tube Expanders ... and Related Accessories



Elliott offers the Automatic Electric Control—an accurate torque-limiting device designed for tube expanding with any standard tapping motor. Also, a complete line of tube expanders, with rotating, parallel, self-feeding rolls. Available in 4 sizes, ranging from ¼ in. to 3½ in. O.D.

Other related accessories include Elliott tube gage, tube plugs, tube pilot, and tube rolling lubricant.

Write for descriptive literature *today*.

Y8-3

ELLIOTT Company
LAGONDA PLANT, Springfield, Ohio

Equipment ...

entire wound stator undergoes the Epa-Seal vacuum-pressure process, which impregnates the coils, eliminates internal voids, and applies the epoxy resin to all external surfaces. Additional protection is given coils where leads enter.

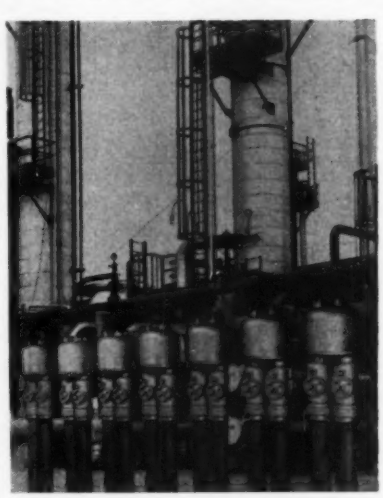
For random-wound motors, the entire wound stator is encapsulated by a vacuum-pressure system that drives the epoxy resin deep into the coil slots, filling them completely. There are no voids, and the tough, resilient, impervious material encloses coils in a homogeneous protective epoxy resin.

To test the effectiveness of the insulation, the company completely submerged an entire form-wound stator in water for three months. Subsequent tests showed that a high level of insulation resistance and dielectric strength were maintained. Likewise, a random-wound motor with the same insulation was run while completely submerged in water for 1000 hours, without failure. Crocker-Wheeler Div., Elliott Co.

Circle E14 green card, last page

Easy Cable Splicing With Above Ground Manholes

A new explosion-proof, dust-ignition-proof, and weather-resistant above-ground manhole condulet, type EAM, provides a convenient means for splicing main feeder cables and making branch taps. They replace the conventional expensive below ground manholes, which are often difficult to work in, due to gas contamination or

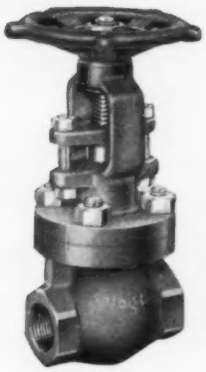


the accumulation of water.

These condulets provide a means for inspecting connections at any time as the covers are easily removable. In addition, the interiors do not have to be filled with hot insulating and water-proofing compound.

Type EAM, listed with and without terminal block, is suitable for voltages up to 600. Deep-dome cover has internal

For more data on advertised products, use Readers' Service Cards, last page.

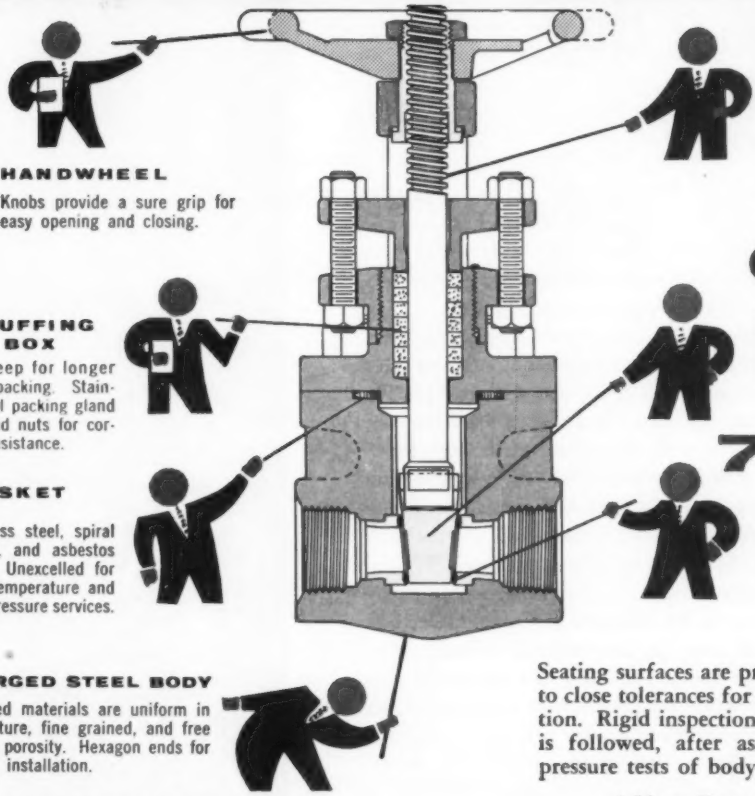


150-800 POUNDS SERVICE
2000 POUNDS COLD, W.O.G.
SIZES ¼" THRU 2"

A NEW Vogt

ROUND BOLTED BONNET, BOLTED GLAND
FORGED STEEL GATE VALVE

with 7 superior features



1 HANDWHEEL
Knobs provide a sure grip for easy opening and closing.

2 STUFFING BOX
Extra deep for longer life of packing. Stainless steel packing gland studs and nuts for corrosion resistance.

3 GASKET
Stainless steel, spiral wound, and asbestos filled. Unexcelled for high temperature and high pressure services.

4 FORGED STEEL BODY
Forged materials are uniform in structure, fine grained, and free from porosity. Hexagon ends for easy installation.

5 STEM
13% Chrome stainless steel. A special high melting point alloy yoke nut assures prolonged wear resistance.

6 WEDGE
13% Chrome stainless steel of approximately 500 Brinell for longer wear.

7 SEATS
13% Chrome stainless steel, hard faced with *HAYNES STELLITE or equivalent for stubborn resistance to seat wear.

Seating surfaces are precision machined to close tolerances for drop tight operation. Rigid inspection of finished parts is followed, after assembly, by final pressure tests of body and seats.

Address Dept. 24A-FPR.

*Trade mark of Union Carbide Chemicals Co.

Vogt GENERAL GP PURPOSE Vogt FOR BETTER VALVES

HENRY VOGT MACHINE COMPANY, Louisville, Ky.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis, Charleston, W. Va., Cincinnati.

FORGED STEEL

VALVES

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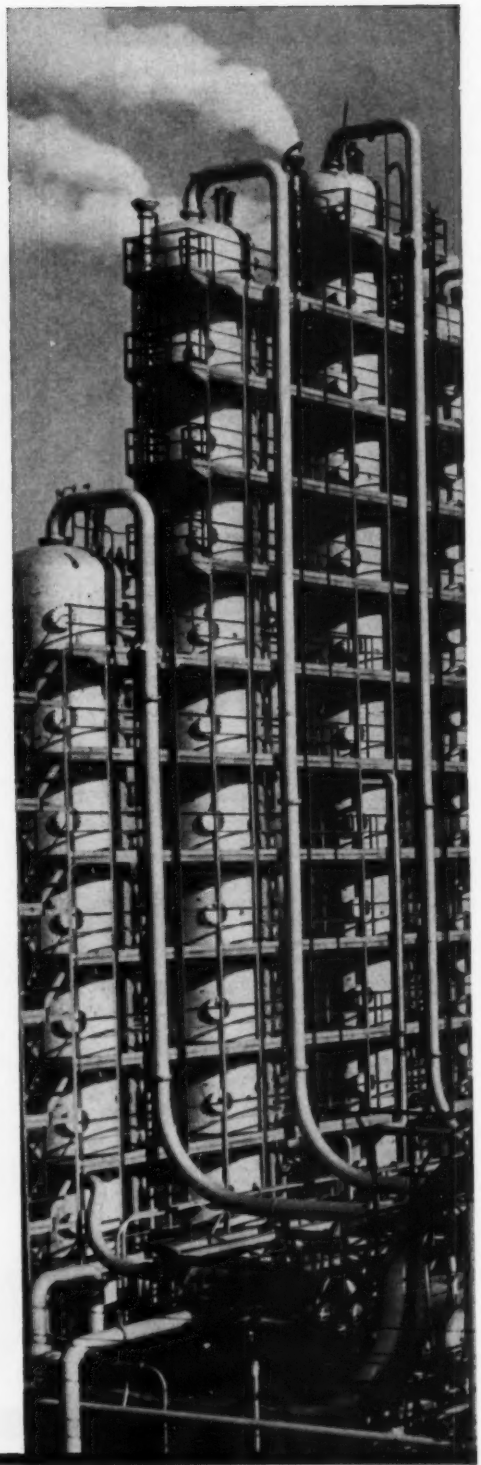
Oakite ECP
engineered cleaning program

races through tower turnaround in under a day



Steaming and washing a 90 foot tower just to remove gas normally took two to three days at one refinery. Labor crews then brushed and scraped for several more days to strip a heavy, crusty deposit from walls, pans, downcomers and 36 trays. Cost of manual labor alone exceeded $2,800.

But with an Oakite ECP, circulation cleaning of the tower was recommended. The refinery pumped a hot Oakite solution through the tower for 12 hours, followed up with 2½ hours of hot and then cold rinses. That did it. The tower was gas-free and completely clean. Cost of materials: only $500.

WHAT IS OAKITE ECP? It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

OAKITE

over 50 Est. 1909 SCIENCE years' leadership in industrial cleaning

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

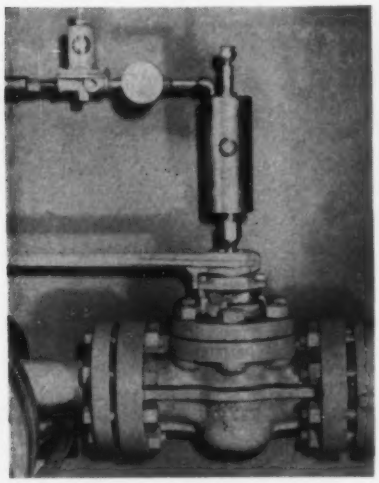
Oakite ECP
your economy key

thread which provides an overlapping junction which will shed rain. The condulet has two 4-inch conduit openings in the bottom, and can be furnished with a maximum of four 1¼-inch branch openings adjacent to the main hubs. Branch openings are drilled and tapped. Crouse-Hinds Co.

Circle E15 green card, last page

Automatic Lubrication For Remote Plug Valves

A new automatic valve lubricator, designed to provide lubricated plug valves with a continuous and regulated supply of lubricant is particularly applicable for remote valve installations where controlled and automatic lubrication is a necessity. Since the lubricator is adjustable—it can



be set to furnish lubricant only when the valve requires it—there is no waste. The operator can tell at a glance when the lubricator is ready for refilling by noting the position of the piston in the lubricator.

The lubricator consists of only three basic parts—piston, cylinder and lubricant chamber. Completing the unit is a pressure regulator. In operation, the piston moves up and down inside the cylinder, telescoping itself over the tubular section of the lubricant chamber. The lubricant is stored only within the hollow piston shaft and lubricant chamber, not within the cylinder.

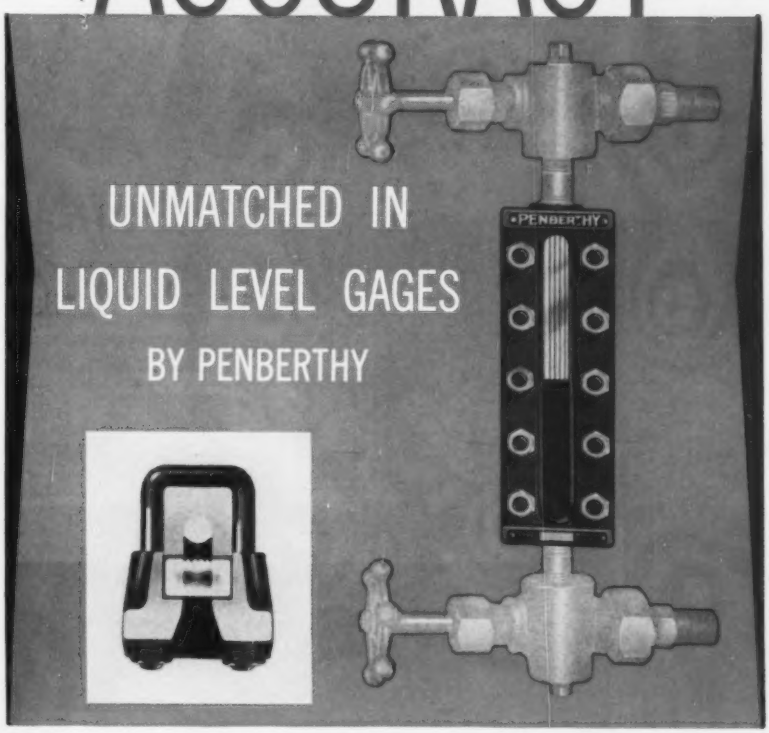
Either air or gas not exceeding 250 psi inlet pressure to the pressure regulator can be used to operate the lubricator. Rockwell Manufacturing Co.

Circle E16 green card, last page

Two Phthalic Anhydride Feed Stocks Using Catalyst

A major innovation in phthalic anhydride process technology introduces an entirely versatile catalyst that permits

ACCURACY



Certainly, your *first* requirement of a gage for determining liquid levels in tanks, pressure vessels, boilers, evaporators and other fluid containers is *Accuracy*. The design, materials and craftsmanship incorporated in the construction of Penberthy liquid level gage sets *guarantee* you clearer visibility, unmatched accuracy . . . at temperatures from sub-zero to 750°F. And Penberthy stands behind that statement with a 74-year reputation for unquestioned leadership in gage development and manufacturing.

You may be sure, too, that Penberthy gages are built to simplify service, reduce maintenance, minimize blowout hazard and, above all, to last longer. Want more information? Mail coupon today.

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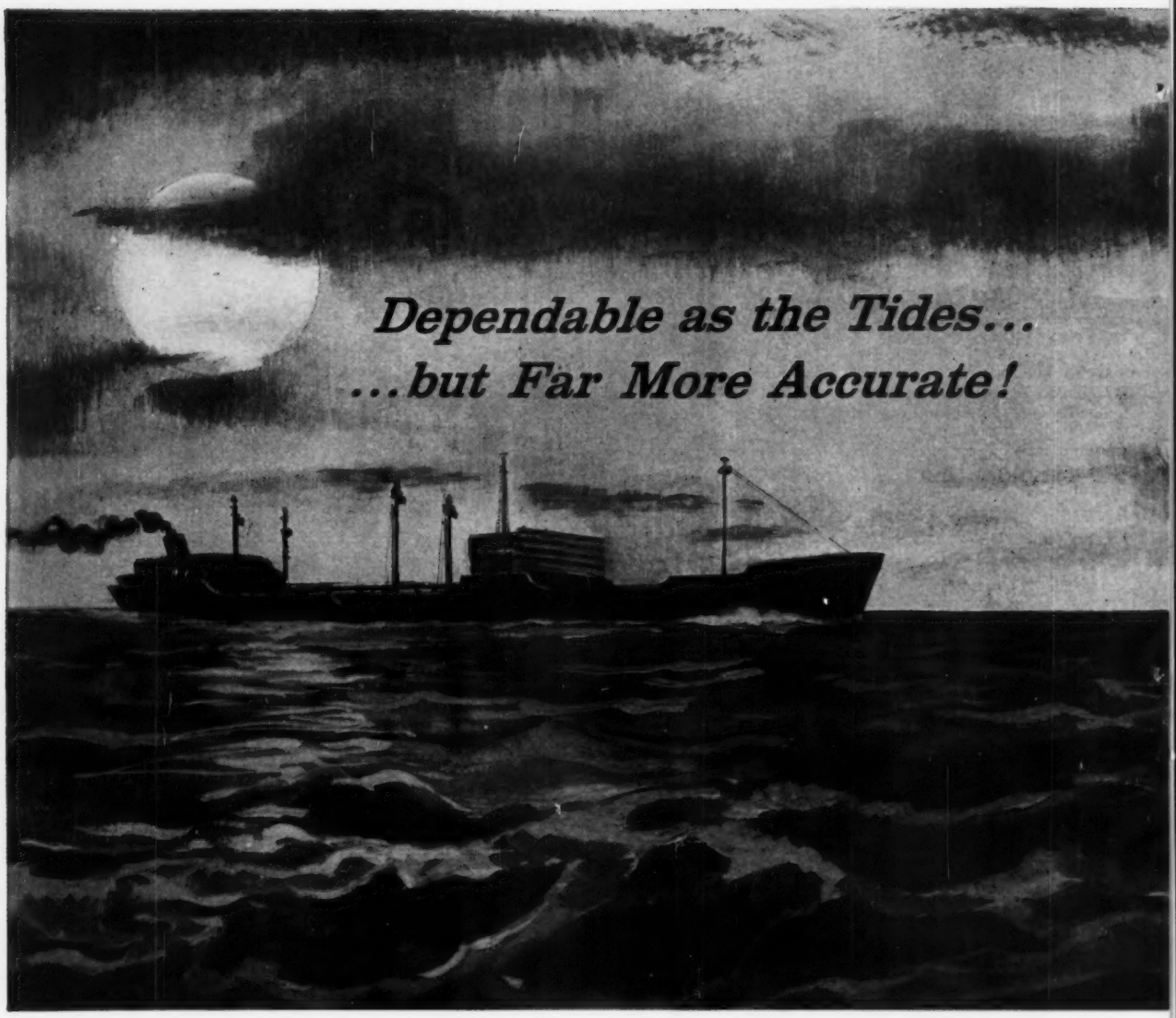

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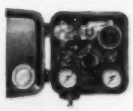

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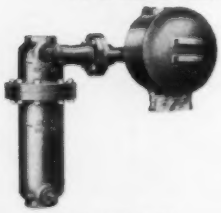


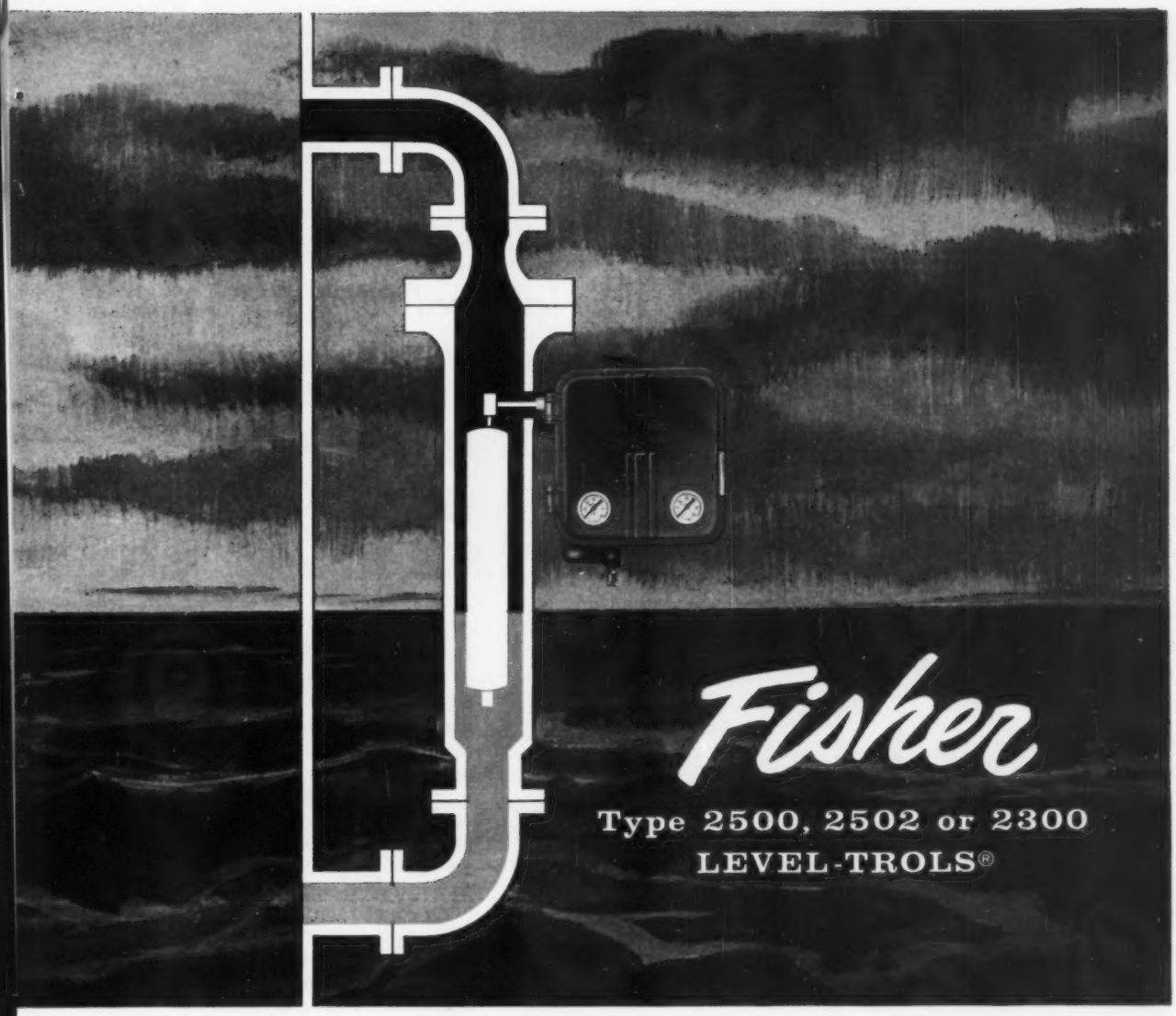
TYPE 2300-249

Wherever Industry Requires

FISHER PROVIDES 3 BASIC LEVEL-TROLS

Fisher Level-Trols operate on the displacement float principle. This, in conjunction with a torsional spring or "torque tube" transmits level changes to the pilot, and provides the simplest and most effective means yet discovered for accurately and continuously measuring liquid level or specific gravity.

The basic simplicity of the design makes the operation of these controllers virtually friction free and accounts for the great popularity they have achieved throughout the industrial world; particularly in the process and power industries.



Dependable Liquid Level Control

THE POPULAR TYPE 2500 PROPORTIONAL CONTROLLER

A compact and economical liquid level controller, the Type 2500, provides a proportional band adjustment up to 100%. It is pneumatically operated and level position is manually adjustable for quick and simple selection of set point. The 2500 is suitable for 3 to 15 psi or 6 to 30 psi output ranges and the action of the controller can be easily reversed in the field. It mounts on all standard Fisher Level-Trol float cages.

TYPE 2502 PROPORTIONAL CONTROLLER WITH RESET

This controller is the most complete single unit liquid level controller available today. It includes, in the same size case, all the features of the Type 2500, plus reset action. It therefore, automatically, brings the set point back to its original position and assures absolutely stable control. Reset rate is adjustable from .005 to 1 minute per repeat.

TYPE 2300 ELECTRONIC LEVEL-TROL

Explosion-proof design and external adjustments for proportional band and liquid level set point, make the Fisher Electronic Level-Trol ideal for use in hazardous locations. Available for output DC signals 1 to 5 ma, 4 to 20 ma or 10 to 50 ma. Has plug-in converter with printed circuit.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

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BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIP. CO., CORAOPOLIS, PA.

FISHER® Controls

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AND NOW... A NEW KIND OF QUALITY GASOLINE...

...the balanced blend made possible by

PENEX®

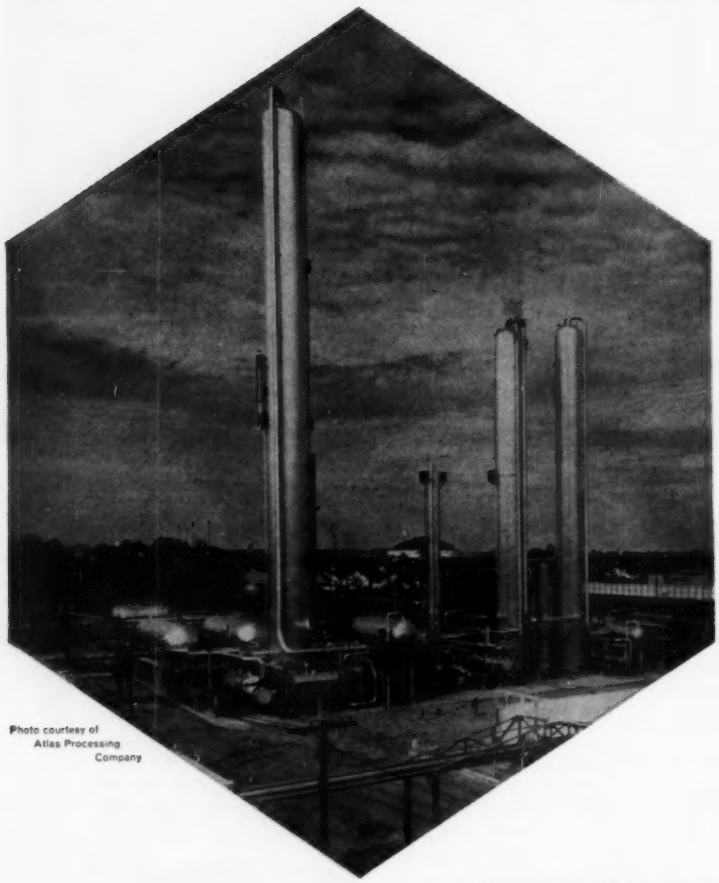

Photo courtesy of Atlas Processing Company

Increasing the aromatic content of motor fuel is the good old-fashioned way to raise its octane number. But aromatics have certain characteristics which limit the concentration you should use in motor fuel. If you want to go further ... produce the *best quality motor fuel* ... your next move is to convert your pentane and hexane fractions to isoparaffins with Penex.

As constituents of fuel, isopentane and isohexane have good sensitivity, complete burning with good ignition, better lead susceptibility and good volatility. Used in a balanced blend with aromatics, they assure production of the *best quality motor fuel now on the market.*

This practical, economical process upgrades your poorest quality blending components, normal pentanes and hexanes ... gives you the isoparaffins you need. A technical bulletin on Penex is yours for the asking. Write for it today.

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WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

Equipment . . .

complete raw material flexibility for the producer.

To the phthalic anhydride producer using a fixed-bed process, the catalyst permits the use at high yield of either naphthalene or ortho-xylene feed stocks, and also mixures of naphthalene and orthoxylene. Scientific Design Co., Inc.

Circle E17 green card, last page

Brochure Covers Corrosion Resistant Filter Details

A new brochure on Duplex corrosion resistant filters gives detailed specification, operational data, and dimensional charts on the complete line of filters in sizes from 2 to 30 inches. Also included are data on the flame-proof electric actuator control system for dual valves, available on filters and for working temperatures up to 300° F. Plenty & Sons, Ltd.

Circle E18 green card, last page

Industry Quiz

(Answers to quiz on page 20)

1. (b) The addition of a pipe loop and one valve makes it possible to put vacuum on only the transfer line. According to authors King and Morgan on Page 101, it's against good safety practice to use pressure on an antiknock system, and lowering the receiving vessel doesn't help prime the transfer line (although, once started, the transfer would be faster).

2. True. George Atkins points out in his article on "How To Specify Fractionating Trays" when and where to use each type of specification, Page 86.

3. False. It's not required of tray deck areas, says G. C. Thrift in his article on "How to Specify Valve Trays" on Page 91. This tray type has no net positive head of liquid on the tray; and therefore, during operation, it cannot leak to the tray below.

4. True. Furthermore, the new computer method described on Page 121 reveals how this one point of operation can be different for different components in the product streams.

5. (c) Howard Bach states in his article on "Tube Rolling Techniques Are Changing," Page 104, that one of the basic purposes in rolling a tube is to get a seal that is free of **longitudinal** tube stress.

6. (a) Normal boiling points are all you need to use the simple equation given on Page 129. It will give you relative volatilities easier and with more accuracy than most other correlation methods.

7. All, according to "How to Check Job Overhead Accounts" on Page 127. Study this list and descriptions again to see how your procedure compares with that used by Chemstrand.

8. (c) They give a greater degree of mixing. Messrs. Patton and Pritchard in their article on "How To Specify Sieve Trays," Page 93, say that large hole sieve trays are probably less susceptible to fouling, that small holes provide a wider range of operating stability, and that trays punched with larger holes may be cheaper because fewer holes are required.

9. False. The lower molecular weight trialkylaluminums (up to C_4) react with all organic compounds except saturated and aromatic hydrocarbons. Turn to "Need More Data on Trialkylaluminums?" on Page 109 and make sure you haven't missed any other important points about these newest petrochemicals.

10. (c) More constant and costly laboratory vigilance is required when using an automatic gasoline blending system according to findings in Sohio's Toledo refinery, Page 97. However, there is a big savings in initial capital investment and the finished blends can be maintained closer to target specifications.

11. True. There are only a few really effective ways to change personality traits. One is psychoanalysis—the other religious conversion, according to "10 Guides to Developing Managers", Page 145.

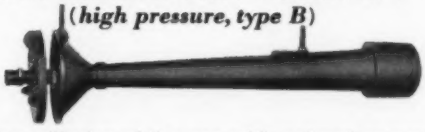
12. False. Even for the newer charts you must be careful when you get within 50 pounds of critical pressure. See Wayne Edmister's article on Page 113 for a clearer discussion on these limitations.

DFC BURNERS

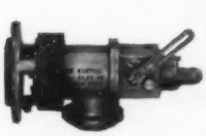
Simple, Rugged, Low Cost

37 DFC Burners engineered for easy, low cost, maintenance-free operation, through long years of hard use. Atmospheric, high and low pressure inspirator, portable, tunnel, gas burners, gas-air mixers, oil burners and blowers. 80 years of burner experience...if you've got a burner problem, let us help you solve it.

INSPIRATOR GAS BURNERS
(high pressure, type B)



Applications: Designed for use with natural or manufactured gas under **2 to 25 PSI.** Gives operational economy at low initial investment for boilers, dryers, heaters, incinerators, industrial furnaces, kilns, petroleum processing equipment and roasters. Nine sizes, from 80 to 24,000 cubic feet of 1,000 BTU gas per hour under pressures of 2 to 25 PSI.



Auto-Ratio Proportioning Oil Burner: Automatically maintains accurate air-oil ratio over entire range. Remarkable turn down ratio—up to 20 to 1. For dryers, heaters, industrial furnaces, kilns and roasters.

Centrifugal Motor Blowers: Low pressure blowers with double inlet and 16-oz. positive pressure series with single inlet, used as source of combustion air for industrial burner systems on boilers, dryers, kilns, industrial furnaces, petroleum processing equipment and roasters.

There's a DFC Burner to meet your requirements

DFO-2A

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Please send me further information on your full line of Industrial Burners.

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KOCH FLEXITRAYS—USED 100% IN LARGEST U. S. PROPYLENE PLANT

SUN OIL COMPANY'S $2,000,000 PROPYLENE PLANT – recently placed in successful operation at Sun's huge Marcus Hook, Pennsylvania, refinery – has a potential capacity of 120,000,000 pounds of high-purity propylene per year. Reputedly the largest operation of its kind in the United States, designed to produce the high-purity propylene required by manufacturers of polypropylene – Sun's new plant is currently producing a material with 99.9% purity from refinery gas streams. KOCH FLEXITRAYS HELP MAINTAIN THAT PURITY! Type "F" Koch Flexitrays–140 in all – were specified 100% in the two distillation towers that comprise the major equipment in the new plant. Considered the most dependable and economical device yet developed for distillation absorption and stripping, Koch Flexitrays often save refineries and chemical plants 20 to 40% on total cost of completed installations! For YOUR next tower – investigate Koch Flexitray before you specify! The extreme flexibility of this low-cost fractionating tray has led to its use in more than 1500 installations.

See our catalog in "Refinery Catalog" — or contact your nearest Koch representative.

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Oakland, Calif., Engineered Process Equip. Co., 600 16th St.
Park Ridge, Illinois, M. B. Fisher, 1521 Courtland Ave.
Pasadena, Calif., Engineered Process Equip. Co., 774 E. Green St.
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Charleston, W. Va., D. D. Foster Co. 411 "D" Street
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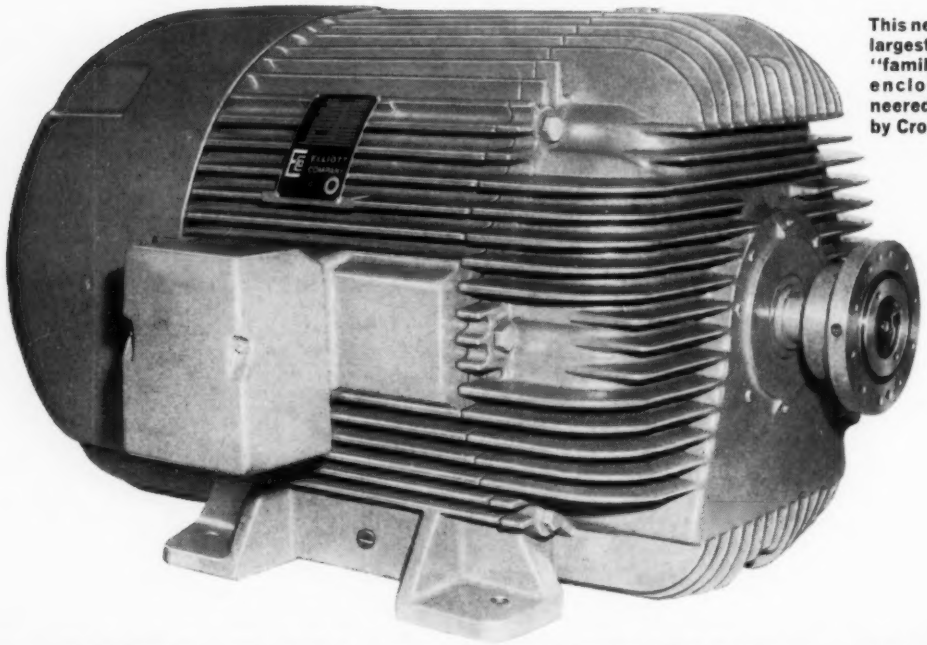


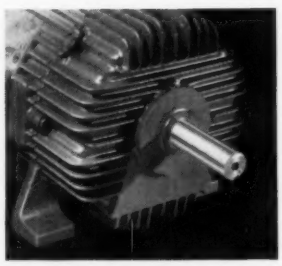
This new 300-hp unit is the largest of the Elliott C-W "family" of ribbed-frame enclosed motors, pioneered in the United States by Crocker-Wheeler.

ELLIOTT C-W SEALEDPOWER MOTORS

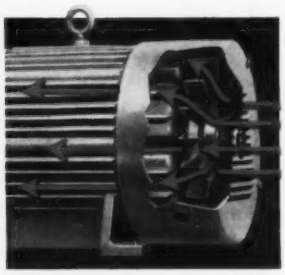
The numerous thin, deep ribs of Elliott C-W SEALEDPOWER Motors are the most advanced development of the ribbed construction, pioneered in the United States by Crocker-Wheeler. Modifications of SEALEDPOWER totally-enclosed fan-cooled motors include explosion-proof designs in all ratings up to 300 hp. Either open greasable or pre-lubricated bearings can be furnished.

Highly-effective sealing prevents entrance of moisture, dust, dirt, corrosive materials; consequently these motors can be depended upon for long, trouble-free service.

In numerous cases, SEALEDPOWER motors are proving to be more economical than standard open motors because of their low maintenance and dependability.



Extra fins keep bearing cool. This potential trouble spot is effectively cooled by the generous extra fins seen in the photograph above.



Cooling blast hugs frame. Air is directed along fins extending entire motor length. Easy to clean — no enclosed cooling passages to clog up.

ELLIOTT Company

CROCKER-WHEELER PLANT JEANNETTE, PA.

Newest data on modern enclosed motors—including explosion-proof—is given in Elliott Bulletin PB 6000-2. Send for free copy today.

W9-2